[*Frontispiece, Vol. xviii.*]

THOMAS WILLIAM EMBLETON.

PRESIDENT OF THE INSTITUTION OF MINING ENGINEERS, 1890-92.

Born on October 4th, 1809, *and died on November 8th*, 1893.

TRANSACTIONS

OF

THE INSTITUTION

OF

MINING ENGINEERS.

VOL. XVIII.—1899-1900.

EDITED BY M. WALTON BROWN, SECRETARY.

NEWCASTLE-UPON-TYNE: PUBLISHED BY THE INSTITUTION.

PRINTED BY ANDREW REID & CO., LIMITED, NEWCASTLE-UPON-TYNE.
1900.

ADVERTIZEMENT.

The Institution, as a body, is not responsible for the statements, facts and opinions advanced in any of its publications.

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THE INSTITUTION OF MINING ENGINEERS.

OFFICERS, 1899-1900.

Past-Presidents (*ex-officio*).

Mr. W. N. ATKINSON, H.M. Inspector of Mines, Barlaston, Stoke-upon-Trent.
Mr. GEORGE LEWIS, Albert Street, Derby.
Mr. J. A. LONGDEN, Stanton-by-Dale, near Nottingham.
Mr. GEORGE A. MITCHELL, 5, West Regent Street, Glasgow.
Mr. ARTHUR SOPWITH, Cannock Chase Collieries, near Walsall.
Sir LINDSAY WOOD, Bart., The Hermitage, Chester-le-Street.

President.

Mr. H. C. PEAKE, Walsall Wood Colliery, Walsall.

Vice-Presidents.

Mr. WILLIAM ARMSTRONG, Wingate, Co. Durham.
Mr. T. FORSTER BROWN, Guildhall Chambers, Cardiff.
Mr. WILLIAM HENRY CHAMBERS, Conisborough, Rotherham.
Mr. WILLIAM COCHRANE, St. John's Chambers, Grainger Street West, Newcastle-upon-Tyne.
Mr. M. DEACON, Whittington House, near Chesterfield.
Mr. JAMES S. DIXON, Fairleigh, Bothwell, N.B.
Mr. J. T. FORGIE, Bothwell Collieries, Bothwell, Glasgow.
Mr. G. B. FORSTER, 3, Eldon Square, Newcastle-upon-Tyne.
Mr. W. D. HOLFORD, Hill House, Old Whittington, Chesterfield.
Mr. JAMES A. HOOD, Rosewell, Midlothian.
Mr. JOEL SETTLE, The Hill, Alsager, Stoke-upon-Trent.
Mr. A. L. STEAVENSON, Durham.
Mr. F. N. WARDELL, Wath-upon-Dearne, near Rotherham.
Mr. R. S. WILLIAMSON, Cannock Wood House, Hednesford.

Council.

* Deceased.

Mr. HENRY ARMSTRONG, Chester-le-Street.
Mr. J. B. ATKINSON, H.M. Inspector of Mines, 10, Foremount Terrace, Glasgow.
Mr. JAMES BARROWMAN, Staneacre, Hamilton, N.B.
Mr. JOHN BATEY, Newbury Collieries, Coleford, Bath.
Mr. G. J. BINNS, Duffield House, Duffield, Derby.
Mr. W. C. BLACKETT, Acorn Close, Sacriston, Durham.
Mr. BENNETT H. BROUGH, Cranleigh House, Woodham, near Addlestone, Surrey.
Mr. M. WALTON BROWN, 10, Lambton Road, Newcastle-upon-Tyne.
Mr. H. M. CADELL, Grange, Bo'ness, N.B.
Mr. JAMES C. CADMAN, Silverdale Collieries, Newcastle, Staffordshire.
Mr. A. G. CHARLETON, 5, Avonmore Road, Kensington, London, W.
Mr. G. E. COKE, 65, Station Street, Nottingham.
Mr. BENJAMIN DODD, Bearpark Colliery, near Durham.
Mr. H. ST. JOHN DURNFORD, Ackton Hall Colliery, Featherstone, near Pontefract.
Mr. T. E. FORSTER, 3, Eldon Square, Newcastle-upon-Tyne.
Mr. W. E. GARFORTH, West Riding Colliery, Normanton.
Mr. CHARLES D. GEDDES, 21, Young Street, Edinburgh.

Mr. JOHN GERRARD, H.M. Inspector of Mines, Worsley, Manchester.
Mr. REGINALD GUTHRIE, Neville Hall, Newcastle-upon-Tyne.
Mr. J. RICHARD HAINES, Adderley Green Collieries, Stoke-upon-Trent.
Mr. JAMES HAMILTON, 208, St. Vincent Street, Glasgow.
Mr. JAMES HASTIE, Greenfield Colliery, Hamilton, N.B.
Mr. W. J. HAYWARD, West Bromwich.
Mr. JOHN L. HEDLEY, H.M. Inspector of Mines, 2, Devonshire Terrace, Newcastle-upon-Tyne.
Mr. T. E. JOBLING, Bebside, Northumberland.
Mr. A. C. KAYLL, Gosforth, Newcastle-upon-Tyne.
Mr. C. C. LEACH, Seghill Colliery, Northumberland.
Mr. G. ALFRED LEWIS, Albert Street, Derby.
*Mr. H. LEWIS, Annesley Colliery, Nottingham.
Mr. HENRY LOUIS, 9, Summerhill Terrace, Newcastle-upon-Tyne.
Mr. M. H. MILLS, Sherwood Hall, Mansfield.
Mr. T. W. H. MITCHELL, Mining Offices, Barnsley.
Mr. JOHN MORISON, Cramlington House, Northumberland.
Mr. J. NEVIN, Littlemoor House, Mirfield.
Mr. H. PALMER, Medomsley, R.S.O., Co. Durham.
Mr. C. E. RHODES, Aldwarke Main and Car House Collieries, Rotherham.
Mr. T. O. ROBSON, Chowdene Cottage, Low Fell, Gateshead-upon-Tyne.
Mr. J. M. RONALDSON, H.M. Inspector of Mines, 44, Athole Gardens, Glasgow.
Mr. F. R. SIMPSON, Hedgefield House, Blaydon-upon-Tyne.
Mr. ALEX. SMITH, 3, Newhall Street, Birmingham.
Mr. E. B. WAIN, Whitfield Collieries, Norton-in-the-Moors, Stoke-upon-Trent.
Mr. JAMES WALLACE, Wester Gartshore Colliery, Kirkintilloch, Glasgow.
Mr. J. G. WEEKS, Bedlington, R.S.O., Northumberland.

Auditors.

Messrs. JOHN G. BENSON & SON, Newcastle-upon-Tyne.

Treasurers.

Messrs. LAMBTON & COMPANY, The Bank, Newcastle-upon-Tyne.

Secretary.

Mr. M. WALTON BROWN, Neville Hall, Newcastle-upon-Tyne.

THE INSTITUTION OF MINING ENGINEERS.

SUBJECTS FOR PAPERS.

The Council of The Institution of Mining Engineers invite original communications on the subjects in the following list, together with other questions of interest to mining and metallurgical engineers.

For selected papers, the Council may award prizes. In making awards, no distinction is made between communications received from members of the Institution or others.

Assaying.
Automatic coupling of mineral wagons.
Blowing out of coal and minerals *in situ*.
Boiler explosions.
Bore-holes and prospecting.
Boring against water and gases.
Brickmaking by machinery.
Brine-pumping.
Canals, inland navigation, and the canalization of rivers.
Coal-getting by machinery.
Coal-washing machinery.
Coke manufacture and recovery of bye-products.
Colliery leases, and limited liability companies.
Compound winding-engines.
Compressed-air as a motive-power.
Consumption of steam and water in engines.
Corrosive action of mine-water on pumps, etc.
Descriptions of coal-fields.
Diamond-mining.
Distillation of oil-shales.
Drift and placer-mining.
Duration of coal-fields of the world.
Electric mining lamps.
Electricity and its applications in mines.
Electro-metallurgy of copper, etc.
Engine-counters and speed-recorders.
Explosions in mines.
Explosives used in mines.
Faults and veins.
Fuels and fluxes.
Gas-producers, and gaseous fuel and illuminants.
Gas, oil and petroleum engines.
Geology and mineralogy.
Gold-recovery plant and processes.
Haulage in mines.
Industrial assurance.
Inspection of mines.
Laws of mining and other concessions.
Lead-smelting.
Light railways.
Lubricating value of grease and oils.
Lubrication of trams and tubs.
Maintenance of canals in mining districts.
Manufacture of fuel-briquettes.
Mechanical preparation of ores and minerals.
Mechanical ventilation of mines, and efficiency of the various classes of ventilators.
Metallurgy of gold, silver, iron, copper, lead, etc.
Mineral resources of colonies.
Mining and uses of arsenic, asbestos, bauxite, mercury, etc.
Natural gas, conveyance and uses.
Occurrence of mineral ores, etc.
Ore-sampling machines.
Petroleum-deposits.
Preservation of timber.
Prevention of over-winding.
Pumping machinery.
Pyrometers and their application.
Quarries and methods of quarrying.
Rectification of mineral oils.
Rock-drills.
Safety-lamps.
Salt-mining, etc.
Screening, sorting and cleaning of coal.
Shipping and discharge of coal-cargoes.
Sinking, coffering and tubbing of shafts.
Sleepers of cast-iron, steel and wood.
Smelting.
Spontaneous ignition of coal and coal-seams.
Stamp-milling.
Steam-condensation arrangements.
Steam-power plants.
Submarine coal-mining.
Subsidences caused by mining-operations.
Sulphur-mining.
Surface-arrangements of mines.
Surveying.
Tin-mining.
Transport on roads.
Tunnelling, methods and appliances.
Utilization of dust and refuse coal.
Utilization of sulphureous gases resulting from metallurgical processes.
Ventilation of coal-cargoes.
Ventilation of mines.
Water as a motive-power in mines.
Water-tube boilers.
Watering coal-dust.
Water-incrustations in boilers, pumps, etc.
Winding arrangements at mines.
Winning and working of mines at great depths.

TRANSACTIONS

OF

THE INSTITUTION

OF

MINING ENGINEERS.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
AUGUST 5TH, 1899.

MR. WILLIAM ARMSTRONG, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting and reported the proceedings of the Council at their meetings on June 17th, July 22nd and that day.

ELECTION OF OFFICERS, 1899-1900.

The PRESIDENT (Mr. W. Armstrong) appointed Messrs. L. Austin, Henry Lawrence, T. Lowden and C. H. Steavenson as scrutineers of the balloting-papers for the election of officers for the year 1899-1900. The scrutineers afterwards reported the result of the ballot as follows:—

PRESIDENT.

Mr. W. ARMSTRONG.

VICE-PRESIDENTS.

Mr. T. FORSTER BROWN.
Mr. J. L. HEDLEY.
Mr. J. H. MERIVALE.
Mr. M. W. PARRINGTON.
Mr. J. G. WEEKS.
Mr. W. O. WOOD.

COUNCIL.

Mr. H. ARMSTRONG.	Mr. H. LAWRENCE.
Mr. H. AYTON.	Prof. H. LOUIS.
Mr. R. DONALD BAIN.	Mr. J. MORISON.
Mr. G. F. BELL.	Mr. R. E. ORNSBY.
Mr. C. BERKLEY.	Mr. H. PALMER.
Mr. T. E. FORSTER.	Mr. J. A. RAMSAY.
Mr. T. E. JOBLING.	Mr. R. A. S. REDMAYNE.
Mr. A. C. KAYLL.	Mr. F. R. SIMPSON.
Mr. PHILIP KIRKUP.	Mr. J. SIMPSON.

Mr. T. LOWDEN moved a vote of thanks to the President, Vice-Presidents and Councillors for their services during the past year, and the resolution was cordially adopted.

Mr. J. K. GUTHRIE moved that a vote of thanks be accorded to the scrutineers for their services, and it was unanimously approved.

The Annual Report of the Council was read as follows:—

ANNUAL REPORT OF THE COUNCIL, 1898-99.

The following table shows the progress of the membership during the past three years:—

Year ending August 1st.	1897.	1898.	1899.
Honorary Members...	29	30	29
Members	829	859	870
Associate Members...	98	115	126
Associates	91	103	109
Students	45	51	62
Subscribers ...	23	22	23
Totals	1,115	1,180	1,219

The members are to be congratulated on the continuing increase of their numbers, which indicates the advancing prosperity of the Institute; 97 names have been added to the register during the past year, and, after allowing for losses by death, resignations, etc., the net increase is 39.

The members have to regret the deaths of Mr. Jeremiah Head, Mr. W. H. Hedley, and Mr. A. M. Potter, who were for many years actively connected with the Institute, and had served on the Council.

The alterations and additions to the Wood Memorial Hall have been completed for about £2,200, a sum somewhat in excess of the estimated cost. The improvement in the lighting, warming and decoration have rendered the hall very convenient, and it now forms a handsome reading- and reception-room for the use of the members.

The portraits in the hall have been increased by those of the late Mr. Nicholas Wood, the late Mr. George Stephenson and Sir Lindsay Wood, Bart. The portrait of the late Sir George Elliot, presented by his grandson, Sir George Elliot, has been placed in the entrance-hall.

The additions to the Library by donation, exchange and purchase have been :—

Bound volumes	260
Pamphlets, reports, etc.	250
A total of	510 titles.

And the Library now contains about 7,999 volumes, and 2,000 unbound pamphlets.

Some of the files of publications have been permanently injured by the neglect of members to return borrowed numbers, but it is hoped that it may be possible to replace them. In consequence, the Council has been reluctantly compelled to decide that unbound *Transactions* and *Journals* shall be withdrawn from circulation.

The Library is becoming very valuable, as it contains books, pamphlets and maps, which could only be replaced at great cost. It has been largely formed by donations from members and exchanges with other societies; and the Council suggests that members can further increase its value by presentations of books, which they may be able to spare from their own libraries. Members would also afford considerable service to the profession by bequeathing their books, reports, plans, etc., to the Institute, who would place them in the Library for reference, and thus maintain the name of the donor in lasting remembrance.

The arrangement is still in force with the Literary and Philosophical Society of Newcastle-upon-Tyne (whose premises are connected with the Library of the Institute), by which members of either Institution are permitted to refer to the books in the library of the other.

The complete publications of the Eleventh Census (1890) of the United States of America have been presented to the Institute, and have been placed in the Library.

The Library also contains the complete publications (maps, memoirs, sections, etc.) of the Geological Survey of Great Britain. They are available for reference by members, but may not be removed.

At the suggestion of the Council, the Durham College of Science has arranged a course of lectures, commencing in October next, for colliery-engineers (*i.e.*, the men in charge of the mechanical plant) similar to that now being given to student colliery-managers. The lectures will be delivered on Saturday afternoons, and the three years' course will be as follows :—

First Year.—First Term, (1) Metallurgy of Iron and Steel, and (2) Pumping and Ventilation. Second Term, (3) Transmission of Power, and (4) Mining Machinery (chiefly used underground).

Second Year.—First Term, (5) Chemistry of Fuel, and (6) Strength of Materials, with experimental illustrations. Second Term, (7) Mensuration, and (8) Experimental Mechanics.

Third Year.—First Term, (9) Theoretical Electricity, and (10) Haulage and Winding. Second Term, (11) The Steam-engine and Boilers, and (12) Electrical Engineering.

The course of lectures will be delivered in cycles of 3 years, like the present mining course, and the fee is 30s. per annum. Several colliery-owners have undertaken to pay the fees and railway-expenses of the pupils attending the classes from their respective collieries.

The annual subscription of Associates and Students having proved inadequate to pay working expenses, it has been increased to £1 5s. The increased charge was adopted, together with verbal amendments to Bye-laws Nos. 8, 9, 10, 11, 12, 14, 15, 21 and 29, at the Annual General Meeting of the members, held on August 6th, 1898, and the changes were approved by the Secretary of State for the Home Department on September 23rd, 1898. Bye-law No. 16 now reads as follows:—

The annual subscription of each Member and Associate Member shall be £2 2s., of each Associate and Student £1 5s., payable in advance, and shall be considered due on election, and afterwards on the first Saturday in August of each year.

The adoption of a composition, varying with age, payable in lieu of future subscriptions, has been generally approved, as evidenced by the number of members who have so compounded. The scale of rates is:—Under 30 years of age, £31; over 30 years, £27; over 40 years, £24; over 50 years, £21; and over 60 years, £17.

The Council has arranged with Messrs. Lambton & Company for the collection of subscriptions, which must in future be paid to them at their bank in Newcastle-upon-Tyne, or at any of their branch banks.

The plant employed by the Explosives Committee in their extensive series of experiments upon explosives used in coal-mines, has been presented, together with surplus furniture, to the Durham College of Science.

Owing to the withdrawal of one of the mining institutes, who assisted in the carrying out of the experiments upon mechanical mine-ventilators, it has been arranged, with the consent of the Midland Institute of Mining, Civil and Mechanical Engineers, that the report of the Committee shall be published in the *Transactions* of The Institution of Mining Engineers.

An Account of the Strata of Northumberland and Durham as proved by Borings and Sinkings has been published in six volumes, and copies may be purchased from the Secretary. Members are desired to send copies of any unpublished sections of strata in these counties, or their section-books on loan, with the view of their being published in a supplementary volume.

A General Index to vols. i. to xxxviii. of the *Transactions* is in the printers' hands, and the Council trusts that it will be received with approval by the members.

The prices of the *Transactions* (vols. i. to xxxviii.) have been reduced, and members are recommended to complete their sets before the stock is exhausted (vols. iii., iv., v., vi. and xxi. are now out of print).

The Council suggests that Indian and Colonial members should establish meetings for the reading and discussion of papers of local or general interest.

Mr. T. Forster Brown represented the Institute at the Conference of Corresponding Societies of the British Association for the Advancement of Science held in Bristol in September, 1898; and Mr. J. H. Merivale will represent the Institute at the conference to be held at Dover in September, 1899. Mr. Henry Davey and Mr. C. L. Simpson will represent the Institute at the meetings of the Sanitary Institute of Great Britain to be held in Southampton in August next; and Mr. John Gerrard and Mr. Jacob Higson at the congress of the Royal Institute of Public Health to be held at Blackpool in September next. Mr. John Daglish acts on behalf of the Institute as a member of the council of the Durham College of Science. Mr. W. Cochrane is the representative of the Institute on the Science and Art Committee, and Mr. Henry Ayton on the Scholarships Committee of the Northumberland County Council.

The Council congratulates the members on the success of the general meeting held recently in the iron-ore mining districts of Furness and East Cumberland, and consider that the thanks of the Institute are due to the committee, who made the very excellent arrangements, and to the writers of papers. The thanks of the Institute are also due to the Barrow Hæmatite Steel Company, Limited; the Hodbarrow Mining Company, Limited; Messrs. Kennedy Brothers; and the Millom and Askam Hæmatite Iron Company, Limited, for allowing the members to visit their works and mines; to the Furness Railway Company for travelling facilities; and to all persons who by their services aided in the holding of that meeting.

Prizes of books have been awarded to the writers of the following papers communicated to the members during the year 1897-98 :—

"Pyritic Smelting." By Mr. Wm. Lawrence Austin.

"Experiments with the Shaw Gas-tester." By Dr. P. Phillips Bedson and Mr. J. Cooper.

"Notes on Rearer Workings." By Mr. John Cadman.

"Occurrences and Mining of Manjak in Barbados, West Indies." By Mr. Walter Merivale.

"The Siliceous Iron-ores of Northern Norway." By Mr. H. T. Newbigin.

"The Gold Regions of Alabama, U.S.A." By Mr. Wm. B. Phillips.

"Hydrothermal Gold-deposits at Peak Hill, Western Australia." By Mr. Frank Reed.

The papers contributed during the year are as follow :—

"Presidential Address." By Mr. William Armstrong.

"The Western Interior Coal-field of America." By Mr. H. Foster Bain.

"The Nullagine District, Pilbarra Gold-field, Western Australia." By Mr. S. J. Becher.

"Results of the Analysis of Samples of New Zealand Coal and Ambrite, and of Barbados Manjak." By Dr. P. Phillips Bedson.

"Report of Delegate at the Conference of Delegates of Corresponding Societies of the British Association for the Advancement of Science, Bristol, 1898." By Mr. T. Forster Brown.

"Davey-Bickford-Smith Safety Shot-igniter." By Mr. G. Chesneau.

"Description of the Pumping-plant at the Stank and Yarlside Mines in the Furness District of North Lancashire." By Mr. Jas. Davison.

"Notes on the Glacial Deposit or 'Wash' of the Dearness Valley." By Mr. T. L. Elwen.

"Fire-damp in the Iron-ore Mines of Cumberland and Furness." By Messrs. John L. Hedley and William Leck, H.M. Inspectors of Mines.

"Description of the Machinery and Process of Iron-ore Washing at the Park Mines in the Furness District of North Lancashire." By Mr. William Kellett.

"The Murgue Recording Volumetric Anemometer." By Mr. D. Murgue.

"Transvaal Coal-field." By Mr. William Peile.

"The Geology of Furness." By Mr. C. E. de Rance.

"The Felling of a Chimney." By Mr. Frank Reid.

"The Ore-deposits of the Silver Spur Mine and Neighbourhood, Texas, Queensland." By Mr. H. G. Stokes.

The Council has pleasure in congratulating the members upon the number and varied nature of the papers printed in the *Transactions*, and trusts that similar excellent communications will be forwarded as liberally in the future.

The Institution of Mining Engineers has completed its first decade. During the past year, meetings have been held in Birmingham on September 13th, 14th and 15th, 1898 ; in North Staffordshire on February 22nd and 23rd, 1899 ; and in London and Peterborough on May 25th, 26th and 27th, 1899.

In concluding their 47th annual report, the Council asks the members to use their endeavours to increase the membership, as the further

success of the Institute will depend upon its being able to find funds for the expenses of Committees appointed to make investigations on subjects of interest to mining or mechanical engineers, and to meet the increased expenses ensuing from its connexion with The Institution of Mining Engineers.

The PRESIDENT moved the adoption of the report.

Mr. T. W. BENSON seconded the resolution, which was unanimously agreed to.

The TREASURER (Mr. Reginald Guthrie) read the Report of the Finance Committee as follows :—

REPORT OF THE FINANCE COMMITTEE.

The Finance Committee submit herewith a statement of accounts for the twelve months ending June 30th, 1899. The accounts up to the same date in the preceding year only covered a period of eleven months, owing to the change in the date to which the accounts were to be made up in each year, which was then adopted by the Council. It is consequently still impossible to make a proper comparison between the two periods. This difficulty will be removed in the year 1899-1900.

The total receipts were, from July 1st, 1898, to June 30th, 1899, £3,943 8s. 2d. Of this amount £128 2s. was paid as life-compositions in lieu of annual subscriptions, £86 2s. 0d. represented subscriptions paid in advance, and the sum of £1,150 was withdrawn from deposit account with Messrs. Lambton & Co., bankers, leaving the sum of £2,579 4s. 2d. as the ordinary income of the year.

The ordinary expenditure amounted to £2,210 16s. 7d., leaving a balance of ordinary receipts over ordinary expenditure of £368 7s. 7d. There was also paid on account of the alterations to the Wood Memorial Hall, £1,900 12s. 6d., the total payments thus amounting to £4,111 9s. 1d.

During the year the sum of £35 14s. has been written off the list of subscriptions and arrears as irrecoverable.

The balance-sheet shows the capital of the Institute at June 30th, 1899, to be £8,145 15s. 10d., but this does not include either the original value of the Wood Memorial Hall or the amount recently expended in its alteration.

Mr. J. G. WEEKS moved the adoption of the report.

The PRESIDENT (Mr. W. Armstrong) seconded the motion, which was unanimously adopted.

DR. THE TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND
FOR THE YEAR ENDING

			£ s. d.	£ s. d.
June 30th, 1898.				
To Balance at Bankers			674 2 5	
„ „ in Treasurer's hands			66 17 0	
„ Outstanding Amounts due for Authors' Excerpts ...			2 5 3	
June 30th, 1899.				743 4 8
To Dividend of 7½ per cent. on 146 Shares of £20 each in the Institute and Coal Trade Chambers Co., Ltd., for year ending June 30th, 1899			219 0 0	
„ Interest on Mortgage of £1,400 with Institute and Coal Trade Chambers Company, Ltd.			73 10 0	
„ Interest on Deposit Account			30 7 4	
				322 17 4
„ Sale of *Transactions*				93 3 10
To SUBSCRIPTIONS FOR 1898-99 AS FOLLOWS:—		£ s. d.		
692 Members	@ £2 2s.	1,453 4 0		
2 „	@ £1 1s.	2 2 0		
			1,455 6 0	
80 Associate Members	@ £2 2s.		168 0 0	
86 Associates	@ £1 1s.		90 6 0	
44 Students	@ £1 1s.		46 4 0	
46 New Members	@ £2 2s.		96 12 0	
26 New Associate Members	@ £2 2s.		54 12 0	
15 New Associates	@ £1 1s.		15 15 0	
13 New Students	@ £1 1s.		13 13 0	
			1,940 8 0	
Subscribing Firms			90 6 0	
New Subscribing Firm			6 6 0	
			2,037 0 0	
To LIFE COMPOSITIONS:—				
3 Members		£77 2 0		
1 New Member...		24 0 0		
1 New Associate Member		27 0 0		
			128 2 0	
			2,165 2 0	
Less—Subscriptions for current year paid in advance at the end of last year...			75 12 0	
			2,089 10 0	
Add—Arrears received			201 15 0	
			2,291 5 0	
Add—Subscriptions paid in advance during the current year			86 2 0	
				2,377 7 0
„ Amount withdrawn from Deposit Account ...				1,150 0 0
				£4,686 12 10

INSTITUTE OF MINING AND MECHANICAL ENGINEERS. Cr.
JUNE 30TH, 1899.

	£	s.	d.	£	s.	d.
June 30th, 1899.						
By Printing and Stationery	204	12	7			
" Books for Library	31	12	2			
" Prizes for Papers	9	9	0			
" Incidental Expenses and Sundry Accounts	54	11	10			
" Postages, Telephones and Telegrams	77	8	0			
" Travelling Expenses	1	2	6			
" Salaries and Wages	409	17	10			
" Reporting	12	12	0			
" Rent and Taxes	45	16	6			
" Insurance	8	4	11			
" Furnishing and Repairs	132	17	1			
" Coals, Gas, Water and Electric Light	34	8	4			
" Expenses of Meetings	5	18	0			
				1,028	10	9
The Institution of Mining Engineers	1,184	17	0			
Less—Amounts paid by Authors for Excerpts ...	2	11	2			
				1,182	5	10
				2,210	16	7
" Wood Memorial Hall: Alterations				1,900	12	6
				4,111	9	1
By Balance at Bankers	527	18	9			
" " in Treasurer's hands	47	0	8			
" Outstanding Amounts due for Authors' Excerpts ...	0	4	4			
				575	3	9
				£4,686	12	10

We have examined the above account with the books and vouchers relating thereto, and certify that, in our opinion, it is correct.

JOHN G. BENSON AND SON.
CHARTERED ACCOUNTANTS.

Newcastle-upon-Tyne,
July 28th, 1899.

DR. THE TREASURER IN ACCOUNT

	£	s.	d.	£	s.	d.
To 859 Members.						
1 „ not on printed list.						
860						
43 of whom are Life Members.						
817 @ £2 2s.				1,715	14	0
To 115 Associate Members,						
8 of whom are Life Members.						
107 @ £2 2s.				224	14	0
To 103 Associates @ £1 1s.				108	3	0
To 51 Students @ £1 1s.				53	11	0
To 22 Subscribing Firms				90	6	0
To 46 New Members @ £2 2s.				96	12	0
To 3 Members, paid Life Composition				77	2	0
To 1 New Member, paid Life Composition				24	0	0
To 26 New Associate Members @ £2 2s.				54	12	0
To 1 New Associate Member, paid Life Composition ...				27	0	0
To 15 New Associates @ £1 1s.				15	15	0
To 13 New Students @ £1 1s.				13	13	0
To 1 New Subscribing Firm				6	6	0
				2,507	8	0
To Arrears, as per Balance Sheet 1897-98	£393	15	0			
Add—Fines	1	4	0			
Add—Arrears considered irrecoverable, but since paid ...	6	6	0			
				401	5	0
				2,908	13	0
Less—Struck off as irrecoverable—Arrears...	2	2	0			
„ „ „ Current year	33	12	0			
				35	14	0
				2,872	19	0
To Subscriptions Paid in Advance				86	2	0
				£2,959	1	0

WITH SUBSCRIPTIONS, 1898-99. CR.

			PAID.			UNPAID.		
			£	s.	d.	£	s.	d.
By 692 Members, paid		@ £2 2s.	1,453	4	0	......		
By 2 " "		@ £1 1s.	2	2	0	2	2	0
By 119 " unpaid		@ £2 2s.	......			249	18	0
By 4 " dead		@ £2 2s.	......			8	8	0
817								
By 80 Associate Members, paid		@ £2 2s.	168	0	0	......		
By 26 " " unpaid		@ £2 2s.	......			54	12	0
By 1 " " dead		... ...	......			2	2	0
107								
By 86 Associates, paid		@ £1 1s.	90	6	0	......		
By 17 " unpaid		@ £1 1s.	......			17	17	0
103								
By 44 Students, paid		@ £1 1s.	46	4	0	......		
By 7 " unpaid		@ £1 1s.	......			7	7	0
51								
By 22 Subscribing Firms, paid			90	6	0	......		
By 46 New Members, paid		@ £2 2s.	96	12	0	......		
By 3 Members, paid Life Composition			77	2	0	......		
By 1 New Member, paid Life Composition			24	0	0	......		
By 26 New Associate Members, paid		@ £2 2s.	54	12	0	......		
By 1 New Associate Member, paid Life Composition ...			27	0	0	......		
By 15 New Associates, paid		@ £1 1s.	15	15	0	......		
By 13 New Students, paid		@ £1 1s.	13	13	0	......		
By 1 New Subscribing Firm, paid			6	6	0	......		
			2,165	2	0	342	6	0
Less—Struck off as irrecoverable			......			33	12	0
						308	14	0
By Arrears			201	15	0	197	8	0
By Subscriptions paid in advance			86	2	0	......		
			2,452	19	0	506	2	0
						2,452	19	0
						£2,959	1	0

General Statement, June 30th, 1899.

Liabilities.

	£	s.	d.
Subscriptions paid in advance during the year	86	2	0
The Institution of Mining Engineers	60	5	0
Capital	8,145	15	10
	£8,292	2	10

We have examined the above account with the books, vouchers and securities relating thereto, and certify that, in our opinion, it is correct. We have accepted the "*Transactions* and other Publications" as valued by your Officials.

JOHN G. BENSON AND SON,
CHARTERED ACCOUNTANTS.

Newcastle-upon-Tyne,
July 28th, 1899.

Assets.

	£	s.	d.	£	s.	d.
Balance of Account at Bankers	527	18	9			
" in Treasurer's hands	47	0	8			
Outstanding amounts due for Authors' Excerpts	0	4	4			
				575	3	9
Arrears of Subscriptions	......			506	2	0
146 Shares in the Institute and Coal Trade Chambers Co., Ltd. (at cost)	3,130	0	0			
Investment with the Institute and Coal Trade Chambers Co., Ltd. (Mortgage)	1,400	0	0			
				4,530	0	0
(Of the above amount, £350 is due to Life Subscriptions Account, leaving £451 14s. not invested.)						
Value of *Transactions* and other Publications, as per Stock Account	......			480	17	1
Office Furniture and Fittings	450	0	0			
Books and Maps in Library	1,750	0	0			
				2,200	0	0
				£8,292	2	10

REPRESENTATIVES ON THE COUNCIL OF THE INSTITUTION OF MINING ENGINEERS.

The PRESIDENT (Mr. W. Armstrong) moved, and Mr. J. K. GUTHRIE seconded, a resolution that the following gentlemen be elected as the representatives of the Institute on the Council of The Institution of Mining Engineers:—

Mr. HENRY ARMSTRONG.
Mr. WILLIAM ARMSTRONG.
Mr. J. BATEY.
Mr. W. C. BLACKETT.
Mr. BENNETT H. BROUGH.
Mr. T. FORSTER BROWN.
Mr. A. G. CHARLETON.
Mr. WILLIAM COCHRANE.
Mr. BENJAMIN DODD.
Mr. G. B. FORSTER.
Mr. T. E. FORSTER.
Mr. JOHN GERRARD.
Mr. REGINALD GUTHRIE.
Mr. A. L. HEDLEY.
Mr. T. E. JOBLING.
Mr. A. C. KAYLL.
Mr. C. C. LEACH.
Prof. HENRY LOUIS.
Mr. J. MORISON.
Mr. HENRY PALMER.
Mr. T. O. ROBSON.
Mr. F. R. SIMPSON.
Mr. A. L. STEAVENSON.
Mr. J. G. WEEKS.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. ERNEST AKERMAN, Mining Engineer and Mine Manager, Minas de Cala pro Sta Olalla, Huelva, Spain.

Mr. CLARENCE R. CLAGHORN, Mining Engineer and Colliery Manager, Vintondale, Cambria County, Pennsylvania, U.S.A.

Mr. JOSEPH CRANKSHAW, Mining Engineer, Montcliffe, Horwich, near Bolton.

Mr. WILLIAM HENRY CUTTEN, Consulting Engineer, Dunedin, New Zealand.

Mr. THOMAS GEORGE DAVIES, Mine Manager, Barrytown, New Zealand.

Mr. FERDINAND DIETZSCH, Mining Engineer, 13, Austin Friars, London, E.C.

Mr. LEONARD RALPH FLETCHER, Colliery Proprietor, The Hindles, Atherton, Manchester.

Mr. JOHN JAMES MUIR, Civil and Mining Engineer, and Authorized Mining Surveyor, North Mount Lyell Consolidated Mine, Tasmania.

Mr. AITARO NOMI, Mining Engineer, Ikuno, Tazima, Japan.

Mr. FRANCIS ARTHUR RICH, Mining Engineer and Manager, Woodstock Gold Mining Company, Limited, Karangahake, Auckland, New Zealand.

Mr. JOSEPH FLEETWOOD WELLS, Mining Engineer, Kamloops, British Columbia.

ASSOCIATE MEMBERS—

Mr. ALFRED G. HAILES, Sejooah Colliery, Katras Post Office, District Manbhoom, Bengal, India.

Mr. JOHN HENRY SCOTT, 1157, Burnaby Street, Vancouver, British Columbia.

ASSOCIATES—

Mr. John DUNN BARKER, Deputy Overman, John Street, Meadowfield, Durham.

Mr. JOHN DAKERS, Under Manager, 32, South Street, Brandon Colliery, Durham.

Mr. CHRISTOPHER KEARTON, Deputy Overman and Mining Student, Rose Cottage, Keekle, Hensingham, Whitehaven.

Mr. JOHN RAW, Miner, Hunwick, Willington.

DISCUSSION OF MR. T. L. ELWEN'S "NOTES ON THE GLACIAL DEPOSIT OR 'WASH' OF THE DEARNESS VALLEY." *

Mr. PHILIP KIRKUP (Cornsay) wrote that Mr. Elwen spoke of the Dearness valley being situated in the "Upper Coal-measures," with which opinion he did not agree. The Permian, where existing in the county of Durham, rests unconformably upon the Coal-measures; in fact, the Upper Coal-measures have for the most part been denuded prior to the deposition of the yellow sand of the Permian, and the Brockwell coal-seam in this part of the county forms probably the base of the Middle Coal-measures. The strata between the Brockwell coal-seam and the Fell Top limestone, consisting for the most part of sandstone and shales with small seams of coal, are probably representative of the Lower Coal-measures.

It is difficult to sub-divide the Coal-measures in the North of England into Upper, Middle and Lower. The Geological Survey attempts to define Upper as comprizing all coal-seams above the High Main coal seam; Middle being those lying between the High Main and the Brockwell coal-seam; and the Lower as those lying between the Brockwell coal-seam and the uppermost bed of the Carboniferous Limestone. Prof. Lebour† did not agree with this classification, but favoured the whole of the strata containing workable seams of coal being called "Coal-measures," without sub-division.

Mr. ROBERT PEEL (New Brancepeth Colliery) wrote that Prof. G. A. Lebour stated that the Brockwell seam "has been looked upon usually as the base of the Coal-measures, but has been taken by the Government Geological Survey as the boundary line between the Middle and Lower Coal-measures or Ganister Beds."‡

* *Trans. Inst. M.E.*, vol. xvii, page 226.

† *Outlines of the Geology of Northumberland and Durham*, page 51; and *Trans. N.E. Inst.*, vol. xxv., page 225.

‡ *Outlines of the Geology of Northumberland and Durham*, pages 39 and 51.

The maximum thickness of the deposit was said to be 100 feet in the Dearness Valley, but the writer had proved a thickness of 120 feet by means of a bore-hole near Ushaw Moor railway-station. The statements that "the effect of this Glacial Drift, primarily, in cutting out large areas of workable seams . . . . . [and that] a considerable thickness of strata with the enclosed coal-seams must have been scooped out of the valley by ice,"* hardly appear to be borne out by the geological evidences in the valley. It seems more probable that most of the strata, and the coal-seams ranging from the Five-Quarter down to the Hutton seam, have been removed by the action of the ancient river and ordinary denuding agents, and that the Boulder Clay and Drift sands-and-gravels are to a certain extent filling up of the old river-valley.

In sinking and in other cuttings through the deposit, many of the boulders found belong to rocks which are foreign to the district. One boulder consisted of brecciated conglomerate, and the writer sends a piece for the examination of the members.

Mr. T. L. Elwen said that he had always assumed that the Lower Coal-measures were those lying below the Mountain Limestone and that those above them were the Upper or true Coal-measures.

The President said that was Prof. D. Page's theory, and was generally accepted as the proper method of division.

Mr. T. L. Elwen, with reference to the surface, said that he was of opinion that the ice had removed a much larger proportion than mentioned by Mr. Peel. The wash was ½ mile wide and 100 feet deep. All glacial drift would be due to the action of ice.

DISCUSSION ON DR. JOHN S. HALDANE AND MR. F. G. MEACHEM'S "OBSERVATIONS ON THE RELATION OF UNDERGROUND TEMPERATURE AND SPONTANEOUS FIRES IN THE COAL TO OXIDATION," ETC.†

The Secretary (Mr. M. Walton Brown) said the interesting part of this paper was that Dr. Haldane showed conclusively, in his opinion, that the spontaneous heating of coal was probably entirely due to the oxidation of iron-pyrites, and thus controverted the theory that the heating was due to the oxidation of the coal or other carbonaceous matter.

* *Trans. Inst. M.E.*, vol. xvii., page 228.

† *Ibid.*, vol. xvi., pages 457 and 495.

The PRESIDENT (Mr. W. Armstrong) stated that iron-pyrites was abundant in the Five-Quarter seam at Wingate Grange Colliery, and a spontaneous fire had occurred, on one occasion, in a place where a heavy fall of stone had taken place, accompanied by a small feeder of water.

Mr. J. G. WEEKS remarked that the oxidation of iron-pyrites was possibly only one of the sources of ignition of spontaneous fires in coal-mines; and that there were probably other causes and circumstances not yet ascertained.

The PRESIDENT suggested that damp air in the presence of iron-pyrites probably would be sufficient to cause spontaneous heating.

Mr. M. WALTON BROWN said that the coal of the Harvey seam occasionally took fire in the entire absence of water. At one colliery, if a jud was shot down and left overnight it was usually found on fire the next morning. Such fires were, however, readily extinguished by erecting a stopping in most cases.

DISCUSSION OF MR. A. RATEAU'S "EXPERIMENTAL INVESTIGATIONS UPON THE THEORY OF THE PITOT TUBE AND THE WOLTMANN MILL."*

Mr. BRYAN DONKIN (London) had read Mr. Rateau's paper with interest and pleasure, as he had made many experiments with both of these instruments for measuring the velocity of air. He quite agreed with the conclusions of Mr. Rateau that both instruments when well made and properly used would give reliable and trustworthy results. The anemometers should be tested in a straight path, or in straight currents of air of known velocity, as in the Breslau experiments. These were made from a gas-holder charged with air.

Before any new experiments with mining-fans are made, the two instruments intended to be used should be calibrated and made to agree, so as to show the velocity of air discharged from a given pipe put up for this purpose. A centrifugal fan could be fixed in such a way as to discharge into the atmosphere through a long straight pipe 18 inches or 2 feet in diameter, fitted with several baffles of woven wire

* *Trans. Inst. M.E.*, vol. xvii., page 124.

or perforated zinc. One of the instruments should be held at the end of this pipe and a mean of several observations taken. To obtain the mean velocity the anemometer may be moved about by hand across the discharge section of the pipe, and the same series of operations afterwards should be repeated with the Pitot tube, keeping all the conditions constant. It is well to note that the air-discharge in such a pipe is at its maximum velocity in the centre, its minimum at the circumference, and its mean at two-thirds of the radius from the centre. The results of the experiments at the centre and two-thirds of the radius should be compared in both instruments, all conditions of speed of fan, etc., remaining constant.

From his experience, he (Mr. Donkin) put more confidence in the Pitot tube than in anemometers, because the former is much smaller in diameter, say, ¼ inch. With anemometers there is always some friction, and the moving parts and vanes should be very carefully made, as Mr. Rateau points out. In addition to this there is the inertia of the revolving blades to be considered.

Air can also be very accurately measured by means of orifices, as proved in the Breslau trials. In experiments with large and small fans, and in mines, the two methods of air-measurement above described are more easily applied.

Anemometers, as usually tested in a circular path, give too high results, and should be used with much caution. An ordinary U water-gauge is often not sensitive enough, and a gauge multiplying the results 10 to 1 is better. With such an instrument a millimetre of water reads as a centimetre, so that 0·1 millimetre can be seen with ease.

Prof. HENRY STROUD (Newcastle-upon-Tyne) wrote that Mr. Rateau's paper is valuable in pointing out the errors that may arise in the use of the Pitot tube and the ordinary anemometer, and the experimental results are also of great interest.

With regard to the author's remarks on the Pitot tube, it is pointed out* that the Pitot tube measures the mean of the squares of the velocities, and not the mean velocity, yet, in the lower table† the calculation of the mean velocity is given, and a coefficient of correction is determined. The experiments show, as was to be expected, that this coefficient is by no means constant.

He thought that it would be interesting to put the table into another form, using the author's data, as follows:—

* *Trans Inst. M.E.*, vol. xvii., page 132. † *Ibid.*, page 131.

No of Experiment.	v_1.	v_2.	v_1^2.	v_2^2.	$\frac{v_1^2+v_2^2}{2}$	$\sqrt{\frac{v_1^2+v_2^2}{2}}$	v.
	m.	m.				m.	m.
1	38·3	30·8	1,467	949	1,208	34·8	34·7
2	36·7	24·1	1,347	581	964	31·0	31·1
3	38·4	25·5	1,475	650	1,062	32·6	32·6
4	37·6	20·4	1,414	416	915	30·2	30·2
5	37·1	16·3	1,376	266	821	28·6	28·6
6	37·1	8·6	1,376	74	725	26·9	26·8

It will be noted how very clearly the experiments show that, as theory indicates, the Pitot tube measures the square of the velocity. In fact the agreement between v (the apparent velocity indicated by the Pitot tube oscillating between two currents) and $\sqrt{\frac{v_1^2 + v_2^2}{2}}$, where v_1 and v_2 are the velocities of the two currents, is remarkably exact, there being practically no difference for any one of the experiments.

Since in Prof. Rateau's experiments v_1 and v_2, are unequal; and v (the velocity given by the Pitot tube) is equal to $\sqrt{\frac{v_1^2 + v_2^2}{2}}$, v cannot be equal to $\frac{v_1 + v_2}{2}$, the mean velocity for the experiments, but is always greater than the mean velocity.

To attempt to calculate $\frac{v_1 + v_2}{2}$ from $\sqrt{\frac{v_1^2 + v_2^2}{2}}$, when the ratio $\frac{v_1}{v_2}$ is quite unknown, appeared to him (Prof. Stroud) to be by no means satisfactory.

Instead of the author's conclusion,* he thought that it would be preferable to state at once that, since the Pitot tube determines the square root of the time-mean of the squares of the velocities, it cannot measure the mean velocity of irregular currents, and that it is inadvisable to introduce a coefficient whose value cannot be determined unless the way in which the velocity changes be known.

With regard to the latter portion of the paper, in his opinion, the ordinary anemometer is certainly unsuitable for measuring very small air-velocities, especially if they are irregular, and he doubted very much the justification of using any formula for such a case with the ordinary form of instrument.

Mr. Charles Chree (Kew Observatory) wrote that he had read the interesting paper by Prof. A. Rateau, entitled "Experimental Investigations upon the Theory of the Pitot Tube and the Woltmann

* *Trans. Inst. M.E.*, vol. xvii., page 161.

Mill." In the limited time at his disposal he had principally given his attention to Prof. Rateau's treatment of anemometers, especially to the mathematical analysis.*

He was surprised to find that Prof. Rateau had been considering the problem of an anemometer exposed alternately for equal times to currents of different constant velocities. He had treated the same problem, but in a more general form, in a paper entitled "Contribution to the Theory of the Robinson Cup-Anemometer."† In his (Mr. Chree's) notation V represented the wind velocity, v the mean velocity of the Robinson cups in a revolution, and the equation of motion which he had solved

was $$\frac{dv}{dt} = -a_0 - a_1 v - b_1 V - a_2 v^2 - 2b_2 v V + c_2 V^2 \quad . \quad . \quad . \quad (1)$$

where a_0, a_1, . . . c_2 are constants for a particular instrument.

The corresponding equation (15)‡ given by Prof. Rateau would be in

his (Mr. Chree's) notation $$\frac{dv}{dt} = -c_2 v V + c_2 V^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

It is derivable from (1) by putting $2b_2 = c_2$, and taking all the other constants as zero.

All the results at which Prof. Rateau arrived in the special problem § could have been obtained at once by making these simplifications in his (Mr. Chree's) formulæ. For instance, Prof. Rateau's solutions (16) and (20) were really special cases of his (27) and (60).

The notation in the two papers was so different that the identity in the steps was not at once obvious. For instance, in the special problem presented by alternate currents of different constant velocities we have:—

Rateau	v,	v_1,	v_2,	$\Omega\rho$,	$\mu\rho$,	τ,	m,	e^{mv_1},	e^{mv_2}.
Chree	V,	V',	V'',	v,	$c_2 = 2b_2$,	$T_1 = T_2$,	$2b_2 T_1$,	$\frac{1}{y'}$,	$\frac{1}{y''}$.

On Prof. Rateau's hypothesis that $2b_2 = c_2$, we have by (2) in the steady state when dv/dt vanishes, or in his (Mr. Chree's) own (60),

$$v = V$$
$$\bar{v}' = v', \ \bar{v}'' = V''.$$

In his treatment of the two-current problem, he did not assume the durations T_1 and T_2 to be equal; he was thus able to trace the influence of the relative durations of the faster and slower air-gusts. He made use of his solution of this problem and analogous ones of somewhat

* *Trans. Inst. M.E.*, 1899, vol. xvii., pages 139 to 152.

† *The London, Edinburgh and Dublin Philosophical Magazine*, 1895, vol. xl., pages 63 to 90.

‡ *Trans. Inst. M.E.*, vol. xvii., 141. § *Ibid.*, vol. xvii., pages 141 to 143.

greater complexity in establishing the very result reached by Prof. Rateau, namely, that an anemometer gives in general too high a value for the mean velocity when the wind is variable.* This conclusion, he might add in passing, had been put forward by some authorities without proof, as a self-evident consequence of the inertia possessed by all anemometers. These authorities had, it seemed to him, overlooked the fact that while inertia tends to keep an anemometer in motion after a gust has ceased it has a compensating tendency while the wind is rising. In reality, a great deal depends on the way in which the wind-velocity alters, and much might doubtless be learned from experiments such as those of Prof. Rateau.

The general equation (29 or 30) proposed by Prof. Rateau for the relation between a steady wind-velocity v, and n the number of divisions traversed by the index of the anemometer in unit time, is

$$v = a + bn + \frac{c}{v},$$

otherwise

$$c + av + bnv - v^2 = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Here n is proportional to the velocity of the moving part of the anemometer, *i.e.*, to v in his (Mr. Chree's) notation.

His (Mr. Chree's) corresponding equation—numbered (18)—is

$$a_0 + b_1 V + a_1 v + 2b_2 v V + a_2 v^2 - c_2 V^2 = 0 \quad . \quad . \quad . \quad (4)$$

where V, as before, denotes wind-velocity, and $a_0, b_1 \ldots$ are constants. This equation reduces to Prof. Rateau's form if we assume

$$a_1 = a_2 = 0.$$

As pointed out in his (Mr. Chree's) paper, Prof. Sir G. Stokes has advanced arguments in favour of the conclusion that, in a Robinson cup-anemometer, a_2 is small if not negligible. He would prefer, however, not to assume a_2 or a_1 equal to zero until experiment justified the assumption for the particular anemometer under consideration.

Mr. Baumgarten's formula (Prof. Rateau's (25)) is of the type in his notation:—

$$a_0 + 2b_2 v V + a_2 v^2 - c_2 V^2 = 0,$$

i.e., it assumes a_1 and b_1 to be zero, but retains a_2. Prof. Rateau's objection to† Mr. Baumgarten's formula, namely, that the centre of the hyperbola, which it represents when v and V are taken as coordinates, lies at the origin, does not, of course, apply to his more general form (4).

He did not see any explanation by Prof. Rateau as to why he employs an equation of type (2) for variable motion while approving one of type

* *The London, Edinburgh and Dublin Philosophical Magazine*, 1895, vol. xl., page 87, and conclusion 5 on page 90.

† *Trans. Inst. M.E.*, vol. xvii., pages 151 to 152.

(3) for steady motion. The two equations ought, he thought, to merge into one another like his (1) and (4) above, when $\frac{dv}{dt} = 0$.

A number of points to which Prof. Rateau refers will also be found discussed in his (Mr. Chree's) paper, to which he must refer the members for details.

At Kew Observatory, his experience is chiefly of small Robinson cup-anemometers. These are exposed to the natural wind at the same height as the large standard Robinson anemometer. In their case, it is found that the record in very light winds depends so much on the lubrication of the instrument, that it is doubtful how long the data obtained will apply in practice. A great deal must depend on the purity of the atmosphere where the instrument works, and on the attention that it receives. Besides Robinson cup-anemometers, the Kew officials have tested a moderate number of fan-anemometers—or "air-meters"—used for recording ventilation. These are compared on a whirling-machine.

Some experiments have been made at Kew Observatory on the effects of altering the distance of the air-meter from the axis of the whirler—*i.e.*, altering the "centrifugal force"—for a given velocity at the air-meter. When, however, such experiments are made—as these have been—in a room of only moderate dimensions, there are various sources of uncertainty, and he (Mr. Chree) was not prepared meantime to say anything definite on this point. If the question is of sufficient practical importance to engineers it might well be brought under the notice of the authorities of the proposed National Physical Laboratory.

In the early part of Prof. Rateau's paper dealing with the Pitot tube, he (Mr. Chree) thought that some reference to the mathematical theory laid down in the text-books* would be useful. Many mathematicians, he was sure, would be glad to know what view engineers take of the formulæ in the text-books which they are accustomed to use.

One final word on the terminology. He did not know whether engineers are accustomed to apply the term "hydrometer" to an instrument intended to measure current-velocities. Such a usage seemed to him regrettable, in view of the long and general application of the term to instruments employed in measuring the density of fluids.

Mr. W. H. DINES (Oxshott, Leatherhead) wrote that he was much interested in Prof. Rateau's paper, and could not help noticing how in many respects he has reached the same conclusions as he had done,

* Mr. Lamb's *Hydrodynamics*, pages 26 to 28.

although it was quite plain that he had not seen the account of his (Mr. Dines's) experiments on the same subject. Thus the statements about the Pitot tube * are very similar to those published in the *Quarterly Journal of the Royal Meteorological Society*.† His experiments, however, were made in an entirely different manner, namely, by moving the instrument in a circle of 28 feet radius at speeds up to 70 miles an hour. Also a very similar suggestion with regard to the Dubuat paradox ‡ would be found in the *Report of the Chicago Meteorological Congress*. §

There can be very little doubt that the irregularity of the air-current caused an exaggeration of the mean velocity recorded, but he thought that in the case of the natural wind (and it is to this case only that his experience applies) the error seldom exceeds 10 per cent., and never greatly exceeds 20 per cent.; also, he was of opinion that the error is much greater in the case of the tube-anemometer, of whatever form, than in the windmill style of instrument. The Pitot tube measures the mean increase of pressure caused by the current, and although this may be translated into velocity on the scale, yet it is the velocity corresponding to the mean pressure that is given, and this must inevitably be above the true mean velocity, save in the one case of perfectly uniform motion.

In using any form of tube-anemometer it is most important to measure the difference of pressure between two openings exposed to the same current, but the form shown in the diagram || seemed very unsuitable, because it is practically impossible to keep the guard-plate exactly parallel to the current. In an arrangement dependent on one opening there is no security that the pressure at the mouth of the tube is measured against the standard barometric pressure then prevailing, and in consequence a large error in the recorded velocity may occur.

In Prof. Rateau's experiments with ¶ the anemometer swinging on a pendulum it appeared to him that the motion due to the pendulum may possibly introduce a disturbing effect. Unless this motion be very small when compared with v_1 or v_2, the air-currents are not relatively parallel to the axis of rotation of the sails, and although the component of the velocity parallel to this axis is unaltered, yet the registration may be effected, for he had found by experiment that an anemometer of the windmill type does not show the proper component when its axis of rotation is inclined to the wind.

* *Trans. Inst. M.E.*, vol. xvii., page 128.
† October, 1890, page 208.
‡ *Trans. Inst. M.E.*, vol. xvii., page 132.
§ Page 701.
|| *Trans. Inst. M.E.*, vol. xvii., page 128.
¶ *Ibid.*, vol. xvii., page 132.

He could not agree with Prof. Rateau's statement.* He had constructed a whirling-apparatus with a very thin arm ($\frac{3}{8}$ inch by 7 inches with the edges sharp, the arm being 8 feet long and stayed by fine wire), but this did not do away with the necessity of the correction. This was shown by the fact that the reading of an anemometer corresponding to one single turn was different if the turn were taken when the apparatus had been some time at rest, and if it were taken immediately after it had been some time in use. To estimate the amount of the correction he used a very thin sheet of mica hung like an inn sign-board, and plàced just outside the path of the anemometer: the deflexion of the mica being noted just before the instrument passed the spot. He had no hesitation in saying that this correction cannot be assumed to be a simple percentage of the velocity, and that its correct estimation is a matter of great difficulty.

The following paper by Mr. John J. Sandeman on "The Mineral Resources of Tasmania" was taken as read:—

* *Trans. Inst. M.E.*, vol. xvii., top of page 161.

THE MINERAL RESOURCES OF TASMANIA.

By JOHN J. SANDEMAN.

Introduction

Tasmania being an island, and separated from Victoria by the Bass Strait is much cooler than the other Australian Colonies. The rainfall is plentiful, hence the growth of underbrush forms a dense and almost

Fig. 1.—View of Forests from the Curtin-Davis Proprietary Mine, looking North-westward.

impenetrable jungle (Fig. 1). Notwithstanding the numerous streams and humidity of the atmosphere, this thick undergrowth with its overhanging forests of great trees will burn with great fury; therefore precautions to provide against fire in the vicinity of the mines are absolute and expensive necessities; on one occasion, it was only by such precautions that the writer saved the works and buildings of a company for whom he was acting as general superintendent.

The prospector deserves admiration and respect in most parts of the world, but especially so in the bush of Tasmania. No pack-animals can penetrate the tangled vegetation, and the explorer has to carry his tools and kit on his back, while axe in hand he hews his way, or on hands and knees crawls along the bed of creeks and streams. When a mine is found, the fine timber covering the country is of course a great help; but to build roads through such a country is an extremely difficult and expensive business. Of late years, tramways have been found both more expeditious and useful modes of carriage. From practical experience, the writer has ascertained that the most economical way of building a temporary tramway in the Tasmanian bush is to form a bed of the cleared brushwood, and to lay logs longitudinally along the proposed route to support the sleepers and rails. This sounds like a rough-and-ready contrivance, yet in boggy ground it will be found quite suitable for bringing in supplies, or even machinery; in very soft places it will sometimes sink, but, in such a case, the original supporting material will form an excellent bed for a similar support.

The mineral wealth of Tasmania is so great and varied that it is somewhat difficult to know where to begin. Gold, silver, tin, copper, lead, nickel, bismuth, iron, asbestos and coal are the principal minerals. The colony is not only rich in metalliferous minerals, but also yields a fair proportion of gems. Practical interest has been principally devoted to zircons.

Gold.

The gold-production of Tasmania has varied considerably during the last 17 years; but the variation can be explained by the fact that the Tasmanian mine has been by far the largest producer, and that the tremendous rushes of water to which that mine has been subjected from time to time have temporarily compelled the cessation of work. The maximum production was in 1896, when it reached 62,591 ounces, worth £237,574; the minimum in 1890, 20,510 ounces, value £79,888; for the first half-year of 1898, 29,599 ounces and £114,175, of which the whole yield from the principal gold-field for the first quarter comes from the Tasmanian mine, where the pumps proved unequal to the water-inflow.

As the writer has visited many mines in various parts of the Australian colonies since leaving Tasmania, he is somewhat chary of trusting his memory for the particulars of the geological formation. He will, therefore, take the liberty to copy the following particulars from the *Australian Mining Standard*:—

In its geological structure, the Beaconsfield gold-field [in which the Tasmanian mine is situated] shows much more variety than we usually find in country carrying auriferous lodes. . . . The crown of the Cabbage-tree Hill [site of the Tasmanian mine] is composed of conglomerates and grits, which lie upon slates and sandstones seen farther to the west. On the eastern side of the hill we find well stratified beds of sandstone, very hard and much jointed, which become finer in grain as we go eastward and pass into laminated slates. These, again, are succeeded by a huge bed of blue [grey] crystalline limestone, some 200 to 300 feet in thickness, and this, again, by a succession of slate, schist and limestone strata. The whole formation forms a conformable series, striking from north 42 degrees west to north 56 degrees west, and dipping to the north-east at an angle of about 65 degrees. In the crown of the ridge, the strata shows subsidiary anticlinal and synclinal folds, but on the whole the general dip is as stated. In some of the sandstone-beds a few fossils occur, from which the age of the strata has been determined to be early in the Lower Silurian period. Towards the Tamar [river], the Silurian strata are overlain by horizontally-bedded sandstones and mudstones of the Permo-Carboniferous system, but these, which, doubtless, once covered the whole of the countryside, have been quite removed by denudation from the slopes of the Cabbage-tree Hill.*

Tasmanian Mine.—Up to January 31st, 1898, this mine yielded 350,625 tons of stone, working at the rate of 1 oz. 3 dwts. 21 grains per ton, worth £1,517,314. Dividends were paid to the amount of £667,161. The company was formed in 1877, with a capital of £300,000 divided into 60,000 shares of £5 each, of which 3,000 are fully paid, 57,000 paid to £2 8s. each, and 1,785 paid to £2 8s. are held in trust by the company. A very large amount of work had been done on this mine, and from the 400 feet level the ground had practically been stoped for 1,400 feet. The lode is from 2 to 30 feet wide; at the lower level (717 feet) it averages about 7 feet. In the wider and poorer parts of the lode, it runs only to 16 dwts. 17 grains to the ton, but this is without the pyrites, which may safely be allowed to bring the yield to over 1 oz. per ton.

There are six shafts on the property, two of these are not now used, while a third is kept for sending down timber, etc. These three shafts originally had pumps in them, the largest shaft (12 feet by 6 feet), however, proved sufficiently large to raise the water; though a new shaft (18 feet by 9 feet) has now been sunk 837 feet, with levels at 59, 494, 600 and 717 feet. As the water comes in at the rate of over 2,000 gallons per minute, powerful pumps are required.

In the main shaft, there are two wrought-iron columns 24 inches in diameter and three sets of plungers, the bottom lift being plunger. The engine has two tandem horizontal cylinders: the high-pressure cylinder

* "Tasmania and Its Mineral Wealth," special issue, July 1st, 1898, page 49.

being 46 inches in diameter, and the low-pressure 72 inches. There are 4 Galloway boilers, 27 feet long by 7½ feet in diameter. The engine works at 7 strokes per minute with a stroke of 9 feet. The inflow of water is tremendous, the western end of the 717 feet level having to be faced with boards, backed by loads of rock, over which the water issues like a roaring torrent; in the eastern end it spouts from a crevice in the hanging-wall, with a jet 7 or 8 inches in diameter.

Although this enormous flow of water has been a great expense to the company, it is utilized to a considerable extent—supplying the battery, and feeding impact water-motors which drive the vanners and the electric-light installation. The train-motor to and from the battery is a Siemens electric motor.

The crushing-plant is divided into three systems of 20, 20 and 25 heads, with three Gates rock-breakers and an automatic feeder to each five heads of stamps, the feed-opening of the latter extending the whole length of the box. The bottom of the quartz-bin, into which the trucks are tipped, consists of a moving perforated tray, which automatically passes the quartz to the rock-breakers, at the same time sieving the material and thus reducing the work of the breakers. The battery screen-area is larger than that of most of the Australian mills, but to the author's mind a still larger area and greater inclination of the screens would be found advantageous. After the amalgamation-plates, there are two classifiers to each system, the finest pulp and slime passing from them over an inverted pyramidal box of the *spitzkasten* type. No blanket-sluices are used, the concentrations, passing over vanners, ranged two and two and back to back, the vanners working in one direction, thus necessitating only one direct shoot for each product.

The discovery of this mine was made by a man named Dally, near the top of an elevation known as Cabbage-tree Hill, from which it was traced to the north-east into the flat below. The strike of the reef is about north 47 degrees east, underlying a little less than 1 in 3. Mr. Montgomery, the Government Geologist, designates it as a fault-fissure displacing the beds of the country, at an angle of 76 degrees, and dipping north-east; the intersection of each bed with the plane of the reef pitching to the east, and the shoots of gold follow the same direction. The reef is broken by several faults, the largest of which heaves it 230 feet to the north; the next largest fault heaves the lode 40 feet at a short distance from the surface, 62 feet at the 59 feet level, and 101 feet at the 717 feet level. On the western side, the reef appears to change its course to a north-westerly one. Mr. Montgomery, how-

ever, is of opinion that the reef has not yet been found on the western side, that supposed to be such being a cross-reef. Whatever may be the correct explanation, so little gold has been found west of this fault that the mine practically terminates there. The two main faults converge and join to the south of the lode; between them are several small reversed faults, and it seems as though the great wedge between the cross-courses had been thrust northward. This faulting is worth studying, for though unusual, it is not exceptional, a similar case having come under the writer's observation, on a small scale, in California.

Mathinna stands second as a gold-producing district, and like that of Beaconsfield, it owes a great part of its prosperity to the New Golden Gate mine. Although the writer had been through this country on several occasions, he had always been on his way elsewhere, and in a hurry; he would, therefore, treat of it briefly. The geological formation is red clay-slate. The lodes run north and south, dipping to the east, and are generally most productive when the course is a little east of north. In depth, the clay-slates give place to hard blue slate, where the lodes are most productive.

The New Golden Gate shaft is now sunk down to a depth of 1,330 feet. The lode averages about 3 feet in width, and some parts of the quartz pays over 10 ounces to the ton. All stone crushed has averaged 18 dwts. 16 grains per ton. The mine is practically dry, and easily kept free from water without the aid of pumps. The winding-machinery is capable of hoisting from a depth of 3,000 feet. Rock-drills driven by compressed air are used. Lathe, drilling, punching and planing machines are used, also a saw-mill, the latter close to the shaft. The motive power for this work is a Westinghouse engine, which also drives 12 frue-vanners and a Denny-and-Watson pan, a battery of 40 stamp-heads, which, with the frue-vanners and classifiers, form a plant resembling that of the Tasmanian mine. The concentrations run about 7 ounces to the ton, and are shipped to New South Wales for sale. A small copper-plate on the distributing vanner-boxes is found to be advantageous. The cost of raising, crushing, repairs, renewals and all other incidental expenses, including management, was at the rate of £1 11s. 8d. per ton. This company have lately added a complete potassium-cyanide plant to the equipment.

Lefroy.—The writer will now describe a gold-field with which he is well acquainted. He will, however, dispense with an account of the

various mines and plants, none of which prove of more than ordinary interest, while some of them show an extraordinary amount of ignorance and want of ability in development. The blame does not all lie on the mine-managers, some of whom are good practical miners; but before trying to place it he will give two instances of what can be done. One mine with a called up capital of £480 raised 45,000 tons of quartz, from which £124,179 was extracted, and £70,500 paid in dividends. The other one subscribed a capital of £2,300, raised 10,486 tons of quartz, giving 27,700 ounces of gold, valued at £109,000, and paid £60,600 in dividends. In both cases these returns were made in 3 years. One great stumbling-block in the way of mine developments is

FIG. 2.—VIEW OF LEFROY.

the procedure usually followed by the directors of the mining companies. When the mine is producing well, all income is spent in dividends; when dead-work has to be done, these gentlemen give the mine-manager the benefit of their great experience as to what should be done, with the result that the manager leaves, if he knows his business, or else he becomes a foreman under the direction of those who are far better qualified to distribute gold than to mine it.

Lefroy is a rolling country, no hill in that mineral-belt being high enough for advantageous tunnelling (Fig. 2). There is not too much timber and very little undergrowth; but the newcomer finds it difficult to prospect, for the regular formation is in places covered with from 10 to 30 feet of quartz-gravel. The formation is Silurian—slate and

sandstone—the former carrying most of the sixteen lodes with which it is intersected. The lodes themselves are fault lodes, running east-and-west at various angles, the dips being equally irregular. The quartz carries much iron, copper and arsenical pyrites and some sulphide of antimony, the latter being rich in gold in the favoured parts of the lode.

One peculiarity of this district, for which no geologist has yet accounted, is the giving out of the gold at depths varing between 400 and 450 feet. Frequently, the lode continues strong, carrying the pyrites and is apparently the same in all particulars, except the gold. No apparent change in the surrounding formation accounts for this depletion. The writer visited a number of mines, and made most careful examination of the lodes and enclosing strata. It is true that in some cases he observed faults in the formation, which, however, showed no signs of having disturbed the lode. Some of the old miners and local experts attribute the depletion to the volcanic rising of the land above sea-level, maintaining that some liquid, which sought a certain level, had extracted the gold. Mr. Montgomery silenced this theory by asserting that the present level of the country had at one time been below sea-level, and also pointed out that the difference of elevation of the various mines made no difference to the fatal depth of about 450 feet. With all due respect to Mr. Montgomery's undoubted ability as a geologist, the writer begs, however, to suggest that to upheaval may be attributed the different levels of the mines, an upheaval which has probably taken place in comparatively recent times. Mr. Montgomery says also that "the principal cause of the gold giving-out in depth seems to be the disrupting of the stone by faulting movements of the walls." This explanation may apply to a few mines, such as the Volunteer mine, but certainly not to the Chums and the majority of the mines. From mining reports, kindly furnished him by the Agent-General of Tasmania, the writer learns that the New Pinafore mine has struck gold at a depth of 800 feet in the lode, and again at a depth of 1,250 feet in pockets.

East and west of the profitable mineral belt, a ridge of hard slate conformable to the strata (which runs north-west and south-east) forms natural boundaries. As the lodes approach or run into the hard country they become small and finally pinch out. Between these ridges the country is comparatively soft, and the lodes nearest to the centre are the richest in free-milling gold.

From the self-evident facts and the scientific inductions of the late

Government geologist (Mr. Montgomery), it is plain that large areas of gold-bearing gravels are buried in the Lefroy district. Diamond-drills have brought up gold from these gravels, but so far the necessary capital for further and surer information has been wanting. There is one thing certain: the gravels of the district carry more or less gold on the surface, and where the gravels are capped with basalt they have proved rich in coarse gold and sometimes in nuggets. The course of the main deep-lead is known approximately, and some day it will be opened up and cause a boom, for should Mr. Montgomery's theory prove correct, the gold would be plentiful.

SILVER.

Zeehan.—On the West Coast, the Zeehan field is rapidly proving that the writer's impressions of it were correct. This country would have been well known to the public long ago, but it laboured under an epidemic of Australian Broken Hill miners, who brought local prejudice with them, and seemed to imagine that gossan was a sure sign of wealth. Large sums of money were expended on gossan outcrops, while the galena-lodes, from which they were faulted, lay in sight untouched. The advent of men of wider experience and larger scientific knowledge changed the mode of working, and as soon as attention was turned to the galena outcrops, the whole district advanced with rapid strides. The introduction of British capital stimulated business, and although some of that capital has been wasted and misapplied, it has brought with it a soberer and more intelligent class of mine managers. The generally accepted assertion that shafts could not be put down over 20 feet without pumping machinery has proved a fallacy, and the founding of a well conducted school of mines will soon widen the views of some of the "old timers."

The geological formations are principally a dark blue slate and a brown sandstone. The writer was extremely lucky in discovering lodes in this district; his success, however, he owes to a fact not generally recognized—the presence of very small rhombic prisms of a white colour distributed through the soil in the vicinity of silver-lead outcrops. These are soft and brittle, having an astringent, metallic taste. The crystals are probably the result of the decomposition of pyrite, and although not found adjacent to all the Zeehan lodes, yet he never found this white substance without, on further research, finding galena.

The Dundas Silver District.—The writer has not visited this district since the 2 feet gauge railway has been built and the mines have been

partly opened up; yet the impressions left on his mind were vivid enough to remain. All the lodes that he visited were true fissures, and one of them was a contact-vein. The very large quantity of chromate-of-lead crystals on the capping of the lodes is certainly unusual. In Arizona and some parts of Brazil these crystals are found sparsely distributed on a few lodes, and when found are considered excellent indications of richness. The geological formation of Dundas needs careful study: it includes slate, sandstone, and a peculiar fine-grained rock that appears to be about half way between basalt and serpentine. The lodes in the latter formation seem to carry the most lead-chromate crystals; but, from a careful examination of the small cross-cuts at that time, he inferred that this lead chromate will not be found to accompany the lodes downwards. In one place, the writer picked out of the Davis lode a small copper-coloured crystal, which the owner maintained was native copper. Upon testing this crystal subsequently, he found that it was sulphide of cobalt.

The rugged and precipitous character of the Dundas field renders it very difficult of approach, yet, this is more than compensated by the ease with which the mines can be explored by adit-levels. Some of the lodes could be easily intersected at a depth of 800 or 1,000 feet by a cross-cut at the cost of a few hundred pounds. The galena in the lodes is patchy, the principal matrix being carbonate of iron, and judging the lodes by his practical experience in Arizona, he anticipated that sulphide of silver would be found in depth. The writer learns that of late both tin and bismuth have been found in this locality, though he would imagine that the presence of the former metal was very unlikely in any part of the Dundas field that he visited. Notwithstanding the adverse opinions expressed by experts, both before and since he examined the Dundas field, he believed that it has a splendid future, and that the lodes will be worked profitably long after the neighbouring country of Zeehan has been exhausted. Australian and Tasmanian engineers are too much inclined to take Broken Hill and a few other rich mineral centres as a pattern on which the success of all other fields depend; and should the latter prove different in appearance they at once condemn them, thus preventing the advent of capital, and sometimes damaging their own credit as professional men.

TIN.

The tin-production of Tasmania holds, the writer believes, the first place among the Australian Colonies. Up to the end of 1897, this little island had produced 80,000 tons of tin, valued at £6,500,000. Of this, one

mine, the Mount Bischoff contributed about £2,700,000. This mine is situated on an elevation known as Mount Bischoff, which is practically a mountain of tin-ore. On the south or working side, the ground rises with a gentle slope to the summit, whence it falls steeply into the valley of the Arthur river. The mine is worked in three open faces or quarries :—The Brown Face, the Slaughter Face, and the White Face.

The Brown Face (Fig. 3) forms a semicircular quarry over 700 feet in length from end to end; at its western end a wall of slate supports it, but

FIG. 3. - VIEW OF THE BROWN FACE WORKINGS OF THE MOUNT BISCHOFF TIN-MINE.

elsewhere the whole length of the huge deposit is dressed off at an angle that enables men to work with safety, while the dislodged ore runs easily down to the ground-level, where it is loaded into trucks drawn by a locomotive. The ore consists of brown oxide of iron, gossan, easy to pick down, and carrying nearly 3 per cent. of black tin ; it is at present 110 feet deep, and has been further proved to a depth of 260 feet. Below the present working-floor, thin veins of cassiterite and masses of tin- and iron-pyrites take the place of the gossan found on the surface.

The Slaughter Face is of similar character, but the gossan is a little harder and more compact ; its full length is 1,000 feet, and it is opened

for about half that distance and about 150 feet in depth. This deposit is 230 feet wide, and the quality of ore still to be taken out represents over a million pounds.

The White Face is an alluvial deposit, 1,500 feet in length from east to west, and 400 feet from north to south. It averages at present about 30 feet deep, sloping upwards from a few inches to 70 feet, and carries 2¾ per cent. of black tin—all parts of the face equalling from 2 to 3 per cent. The floor consists of boulders of carbonate of iron, magnetic pyrites, blende and clay; but, however, it carries little or practically no

FIG. 4.—VIEW OF THE LOWER WORKINGS OF THE MOUNT BISCHOFF TIN-MINE.

tin, though it has been sunk to a depth of nearly 100 feet, without any change. The same, or very similar, materials are found at the eastern and western extremities of the other faces.

A drift has been driven completely through the mountain; it passes under the Brown Face at a depth of 260 feet, where a level has been driven 700 feet on a lode 5 feet wide, and carrying 17 per cent. of tin.

Mount Bischoff may be described roughly as a mountain of slate and sandstone intersected by a great dyke of quartz-porphyry running north-

eastward with numerous branching dykes. In some places the main dyke consists of topaz-porphyry; it carries most of the tin, the branching dykes being barren.

Less than $\frac{1}{2}$ per cent. of tin is lost in the tailings. Yet, with a comparatively small capital, Mr. H. W. F. Kayser, the able manager, has overcome enormous difficulties so as to supply the mill and other machinery with sufficient motive power; all the available streams in the vicinity have been compelled to contribute their part; 7 miles of water-races have been constructed and 11 dams of 800,000,000 gallons total storage-capacity (Fig. 5). This work has been accomplished under

FIG. 5.—VIEW OF THE DAMS FROM THE BROWN FACE WORKINGS OF THE MOUNT BISCHOFF TIN-MINE.

great difficulties, for the mine is elevated above most of the surrounding country. To make the most of the available supply, 7 overshot water-wheels, averaging 30 feet in diameter, have been constructed, one below the other, so that the same water may drive them all. Seventy-five heads of stamps are used, the product is classified into sand and slime, the latter being elevated by hydraulic jets, and the former passes into 30 double-compartment Hartz jigs. The slimes are further treated on 39 convex rotating-tables from 10 to 15 feet in diameter; each table takes 8 cwts. of slime per hour, and requires $\frac{1}{8}$ horsepower to drive it. The sand

from the jigs passes into 15 concave buddles (20 feet in diameter). The jigs save 75 per cent., the concave buddles 4¾ per cent, and the slime tables 15 to 20 per cent. of the tin. The dressed ore is cleaned in dressing-tubs and sent by rail to the nearest sea-port, whence it is shipped to Launceston and treated in small reverberatory furnaces, the total loss in smelting being 4½ per cent. It is estimated that the Mount Bischoff mine has enough ore in sight to run for 10 years without the necessity of touching the exposed pyritous products, and that it will continue to occupy the same position in the tin world that Mount Morgan occupies as a gold-producer.

FIG. 6. – VIEW OF THE DRESSING-SHEDS OF THE MOUNT BISCHOFF TIN-MINE.

The Blue Tier District is a part of Tasmania that requires more careful attention, and more experienced miners than it has yet received. Prof. Ulrich speaks of the Blue Tier mines as stockworks, and Mr. Montgomery describes them as intrusive dykes of stanniferous granite. As far as the writer's experience goes, Prof. Ulrich is most certainly wrong, and Mr. Montgomery as surely correct. The Anchor tin-mine may be a stockwork (he had not been to it), but if it is a stockwork, it differs materially from all others.

For 30 years the Blue Tier mine has been famous for its great stanniferous dykes. The *débris* from these ore-bodies was worked successfully for many years by local companies and prospectors. The question naturally arises, "How can so rich a country have remained practically unworked for so long a time?" Many ill-managed companies have started work, yet, even when successful for a time, a sudden change of managers would again throw them back, or justly frighten the shareholders and entirely break up the company.

The writer estimates that ¾ per cent. of tin per ton would more than pay for mining and reduction-expenses; and as few of the reefs will return less than 1 per cent. there is a good margin for profit. Of course water-power must be utilized, and the shafts should not be sunk (as has been done) in places that necessitate raising the ore 25 or 30 feet above the landing platform; and batteries of established utility must be erected. With modern appliances, a free-milling stanniferous dyke is not expensive to work, provided that the manager is a mining engineer in the true sense of the word. The New Moon, Old Macgough and other properties have been stopped through bank failures and the want of high-class machinery; yet the development of the Anchor, Liberator and Australia mines will surely bring these and other properties to the position that they should have occupied several years ago. The Blue Tier mine occupies the summit of a steep mountain-range, and therefore the lodes could be tapped by a tunnel at almost any practical depth. To accomplish a task of this character, the properties should be amalgamated (an almost impossible task under local companies) or the mining laws receive an additional law regarding tunnel rights—that of the United States dealing with the subject is excellent.

The entire mining code of Tasmania needs careful revision, and no better proof of this fact can be offered than the fact that its provisions are constantly evaded by speculators. The writer once made a similar remark to a Commissioner of Mines, to which he replied indignantly that "the Mining Act and regulations were the prospectors' Bible."

COPPER.

With regard to the rapidly increasing copper-production of Tasmania, the writer draws the following information from reports of the Mount Lyell Mining Company.

The Mount Lyell is not only one of the greatest mines in the southern hemisphere, but it may be said that, judged by its prospects, it occupies a foremost place among the foremost mines in the world. This

district and the rest of Tasmania is a country of magnificent possibilities, which require only capital and energy to become probabilities. Her coal-production is limited by the local demand, and is capable of large development. With plenty of coal, timber, and water she must certainly advance rapidly, especially as the climate is free from extremes of heat or cold. After all the boasts and promises of company-promoters it has been reserved for the Mount Lyell Company to convert promises into performances, redeem the credit of the colony, and lift it into prominent position as a field of remunerative enterprise.

This company, like most of those in Tasmania, is a no-liability company—a form of commercial enterprise of small risk and large prospective profit.

The following extract* from Mr. Peters' report may prove interesting:

From the northern slopes of Mount Owen, . extending . . . some 30 miles north-westerly, a wide band of hydro-mica schist stretches through the country, interspersed with bands of conglomerate and quartzite, and containing numerous intercalated layers of pyrites, mostly of small size. In most places the pyrites is simply disseminated in bands through the country-rock, and, so far as I have determined, it carries copper, gold and silver, in about the same proportions as does the great mass of the Mount Lyell mine, thus differing from the latter only in size. The rapid decay of the soft schist has set free the pyrites contained in it, which in its turn has quickly decayed, the sulphide of iron and copper dissolving in the water, together with most of the silver, whilst the gold, being almost insoluble, has collected in the gravel in the valley below, thus forming the alluvial deposits of the Linda valley. The above explanation is of considerable importance, for the occurrence of a moderately rich alluvial deposit in the valley immediately below the . . . mine, and from which it was evidently in part derived, has originated the mistaken idea that wherever in this belt alluvial gold is found, a great deposit of pyrites may be expected in the hills above it.

This is true in a certain sense, but practically it is . . . misleading, for although the gold is no doubt derived from the decomposition of the pyrites, yet the pyrites that furnished it need not necessarily be in a concentrated and workable form. On the contrary, it is much more likely to come from the thin layers disseminated through the great band of schist referred to, and the existence of an enormous mass of pyrites, as at Mount Lyell, might simply make the alluvial ground below it somewhat richer than usual. And, indeed, this is just what we find in practice, the only profitable alluvial grounds hereabouts being immediately below your great ore-body; whilst every gully that heads in this belt of schist carries the same fine particles of gold, but not in sufficient abundance to pay for working it with the limited water [-supply] hitherto available.

Yet this argument does not in the least forbid the occurrence of similar great bodies of pyrites. Indeed, experience has taught us that the conditions that cause the formation of these enormous deposits are extensive and far-reaching, and that two or three such bodies are likely to be found in close proximity, either longitudinally or vertically.

* "Tasmania and Its Mineral Wealth," special issue of *The Australian Mining Standard*, July 1st, 1898, page 10.

I dislike exceedingly to indulge in any theorizing as to the formative causes of mines in a business report; but in reality the following remarks pertaining to the manner in which such beds of pyrites as that under examination are deposited, are actually as practical and important as most any portion of my report, as unless one has a clear idea of how these great bodies of the valuable metals in combination with sulphur are originated, one cannot understand either how to work them to the best advantage or to prospect with the best hopes of success for other similar deposits. Hence the necessity for the following brief account of their probable origin, based entirely upon the observation of practical men, and demonstrated to be true of bodies of similar sulphides that may be watched forming at the present day in various countries, though with such slowness that only careful observation, at long intervals, shows the steady growth in them that is taking place constantly. . . . The only thing unique about . [this property, however], is its high percentage of copper, gold and silver in connexion with its great size . . . . but as large deposits that are also as rich are not known. These deposits . . . have probably been formed before the period of mountain-building began in this country; and when the layers of schist, that are now nearly vertical, were in the same horizontal position [as that] in which they were originally laid down. They, or neighbouring rocks, contain particles of iron-pyrites carrying the valuable metals, as is exceedingly common with all varieties of sedimentary rocks. The waters flowing through the gradually decayed and dissolved pyrites, as one can see it doing to-day in most . districts, and the streams flowing into some lagoon or bog-hole, came in contact with the peaty, organic acids that are always found in the waters of swamps, and that have the peculiarity of throwing down the metals out of their solutions. These metals were thus precipitated in the same state that they were originally in the rock, but in a massive concentrated form, instead of being disseminated in minute particles throughout the rocks. In time, the slowly-growing mass of pyrites filled the swamp-hole, or more probably, a chain of holes of great horizontal extent in comparison with the depth; the country was [then] slowly covered with the pebbles that now form the conglomerates, or the mud that we now see in the shape of slates or schists; and the pyrites-beds were buried hundreds of feet under these newer rocks. When the mountains were elevated, these layers of rocks were tilted into their present highly sloping position, and if the upturned edges happened to break across one of these hidden deposits of pyrites, it was brought to the light of day.

Remembering, therefore, that its present so-called width . . was its former depth when in its original position, we may see what an enormous depth we may look for. For what we call depth now was, of course, originally its lateral or longitudinal extent. And we all know that the surface-extent of an ordinary pool is . . . usually many scores of times greater than its depth. As the present thickness (former depth) is over 300 feet, we may reasonably expect its extent into the earth (former surface) will be far deeper than we can follow it [with modern appliances].

The mine is worked in a series of benches extending from top to bottom of the pyrites-deposit. The ore is quarried, broken to convenient sizes for handling, and passed through furnaces without further disintegration. To every 10,000 tons from the open faces, 800 tons are added from a tunnel of high-class ore. So far the development is in its infancy, and fresh reserves of good ore are constantly exposed as the work pro-

ceeds. The haulage to the smelters is effected by an overhead tram, and also on the ground-level by trucks.

Recent workings have been as follows :—

Costs per Ton	1898. £ s. d.	1897 Half-year. £ s. d.	Previous Half-year £ s. d.
Mining operations ...	0 2 4·64	0 1 4·88	0 1 8·27
Overburden removal ...	0 2 0	0 2 0	0 2 0
Smelting operations ..	0 17 9·87	0 16 2·44	0 18 1·64
Converter	0 2 9·18	0 3 7·78	0 3 10·39
Totals	£1 4 11·69	£1 3 3·1	£1 5 8·3

Great inconvenience is caused by the absence of proper roads, the scarcity of first-class miners, and the disinclination of workmen to face wet and stormy weather in the open, where the usual rainfall amounts to from 90 to 140 inches per annum ; and such conditions necessarily raise the cost of development. The company, although of comparatively recent formation, now possess their own railway, extensive repairing and other workshops, brickmaking plant, lime-kilns, saw-mills, smithies and carpentry shops, and a large foundry is in contemplation. The railway was constructed under great difficulties, the supplies having to be packed on men's backs from depôt to depôt, and special arrangements made to surmount steep gradients. Many bridges, amounting to 5 per cent. of the distance, and extensive earthworks had to be erected during continuous storms of rain, which threatened the new culverts with destruction ; one of the bridges is 800 feet in length, and several of the foundation-piles had to be driven to a depth of 60 feet so as to secure suitable foundations ; 450,000 cubic yards were excavated in blasting ground, and the deepest cutting had a vertical height of 70 feet. Extensive landslips interfered with the work. The gauge is 45 inches, the locomotives weigh 24 tons each, and the length of the line is 10 miles ; yet, with all these difficulties the line has stood a severe test—running 18 months without an accident—although some of the grades are 1 in 3. The first furnace was started on June 25th, 1896, the output has been increased with the erection of other furnaces, five of which are now completed and a sixth being finished ; and five furnaces of 1½ times the present capacity of present plant are now being added. The yield from June, 1896, to November, 1897, was :—Total quanty of ore treated 102,175 tons, and the average assay value is 4·724 per cent of copper, 3·839 ounces of silver, and 0·1853 ounces of gold per ton.

The following figures will give some idea of the skill displayed in the smelting operations :—

	Copper. Per Cent.	Silver. Ounces per Ton.	Gold. Ounces per Ton.
Average assay ...	4·699	4·09	0·1904
Extraction	4·314	3·95	0·1912

During the quarter ending September 30th, 1898, about 47,750 tons of ore, containing 1,300 tons of copper, 203,908 ounces of silver and 6,938 ounces of gold, of a gross value of £116,679, was produced. The matte treated weighed 6,922 tons, 3,507 tons of blister copper being produced (of an average assay of 98·83 per cent. of copper), 90,378 ounces of silver and 4,393 ounces of gold.

The PRESIDENT moved a vote of thanks to Mr. John J. Sandeman for his valuable paper, and the motion was cordially adopted.

The late Mr. S. J. Becher's paper on "The Kalgoorlie Gold-field" was read as follows :—

THE KALGOORLIE GOLD-FIELD.

By S. J. BECHER.

In the year 1893, a party of prospectors were pushing their way through the bush eastward from Coolgardie to a reported rush some 50 miles out. Amongst them were three men named Hannan, Shea and Flannigan, one of whom whilst the party were camped *en route* in the vicinity of the present city of Kalgoorlie, then of course uncleared bush, went in search of water, and after the manner of all prospectors kept his eyes open the while for likely alluvial or reefing country. He "specked," *i.e.*, picked up on the surface several pieces of ironstone and quartz carrying gold, around a low ironstone hill. He and his mates, so tradition says, kept the find dark, and made some excuse to remain behind when the rest of the party proceeded on their way. Then these three searched about again, and finding sufficient evidence of the value of their find they accordingly pegged out their ground, and Hannan returned 25 miles to Coolgardie to register their application for a reward claim. Little did they dream then of what future importance to the world at large was their find. When a man makes a good find of gold, especially if there is promise of more to come, his thoughts run rampant, and castles in the air are quickly built, but never could their wildest dreams have forecast the present greatness, and perhaps possible future enhanced greatness, of the Kalgoorlie field. When they pegged out their ground it was amidst the dense silent bush, not a living soul abode within many miles of them; and now, after less than five years, a population of 20,000 people finds employment and occupation within a radius of 5 miles of the same spot.

There, luckily, fell just then some heavy rain, and fresh water lay temporarily in the bed of what is now called Hannan's Lake, situated about 6 miles south of the spot where gold was found. This lake is one of the characteristic "dry lakes" of Western Australia.

The intelligence of the new find quickly spread, and the usual scene of feverish excitement ensued upon the arrival of hundreds of men. The previously silent bush rang with the sound of tree-felling, and the voices of men, and the swish of gravel and sand being shaken about in dishes and shakers.

Alluvial work was primarily confined to the dry beds of small water-courses and gullies, but it was soon found that the auriferous drift extended out over the flats surrounding the low hills. The *locus* of the first extensive workings was immediately east of the present city of Kalgoorlie, and around the hills now known as Hannan's Hill, where Hannan's Reward claim was located, and where the Hannan's Reward Gold Mining Company's leases now exist, and also around Mount Charlotte and Maritana Hill. In the early days, the settlement was known as Hannan's, and is even now locally so called by many men.

Following upon the discovery of the alluvial, which proved to be abundant and often very rich, came finds of gold in outcropping quartz-reefs, supposed to be the parent reefs from which the alluvial gold had been shed in times past. Gold was also found in ironstone-beds capping the low hills. Consequently, gold-mining leases were

FIG. 1.—PANORAMIC VIEW, FROM THE SOUTHERN END OF LAKE VIEW SOUTH MINE, SHOWING THE BATTERY OF THE LAKE VIEW SOUTH MINE AT EXTREME RIGHT HAND, WESTWARD AND ON A HILL IS THE BATTERY OF THE LAKE VIEW CONSOLS MINE, FURTHER WESTWARD AND MORE DISTANT IS THE AUSTRALIA MILL (SMOKE ISSUING FROM CHIMNEYS), WESTWARD AGAIN AND NEARER TO THE FOREGROUND IS THE GREAT BOULDER HILL MINE, AND THE BRICK CHIMNEY INDICATES THE POSITION OF THEIR BATTERY, AND FURTHER WESTWARD, IN THE DISTANCE, THE BUILDINGS AT THE IVANHOE MINE ARE VISIBLE.

applied for, and a considerable amount of ground was taken up. In course of time the field became of sufficient importance to be declared

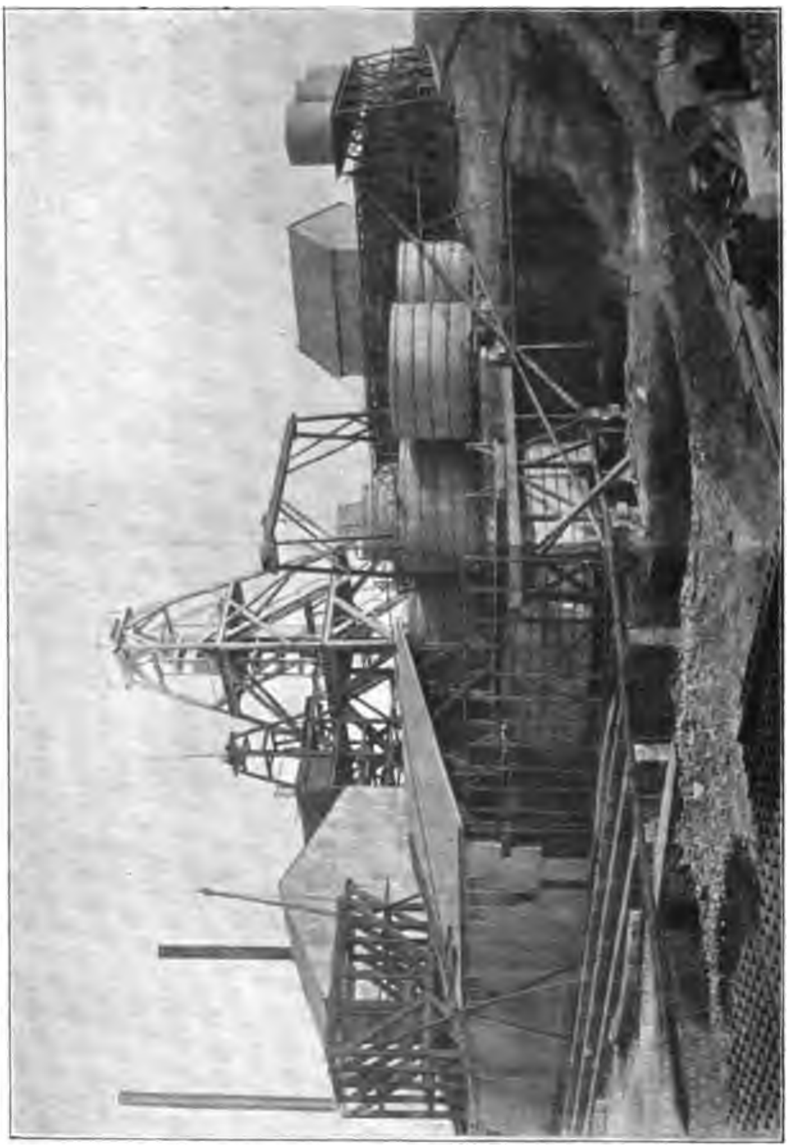

FIG. 2.—VIEW OF THE POTASSIUM-CYANIDE PLANT (IN COURSE OF ERECTION) AND POPPET-LEGS OF MAIN SHAFT OF THE AUSTRALIA MINE.

a gold-field, under the title of the "East Coolgardie Gold-field," and a warden was appointed.

However, as regards mining proper, the field did not go ahead as fast as had been expected. The quartz-reefs proved disappointing, and the following year things were quiet there. Only the quartz-reefs were then, according to old-fashioned precedent, being worked. No one dreamed of "lode-formations."

Then came a very depressed state of affairs in mining matters generally for Western Australia. The boom was over, and the reaction had set in. The glories of the phenomenally rich bunches and pockets in the reefs at Coolgardie had waned, and the "wild-cat" business had nigh brought ruin upon the land.

Just when matters were in a very critical state, good tidings came from Kalgoorlie. At the Great Boulder mine, situated about 3 miles from the settlement, it was found that gold existed throughout an ore-body or lode-formation which had no outcrop. Similar conditions were found

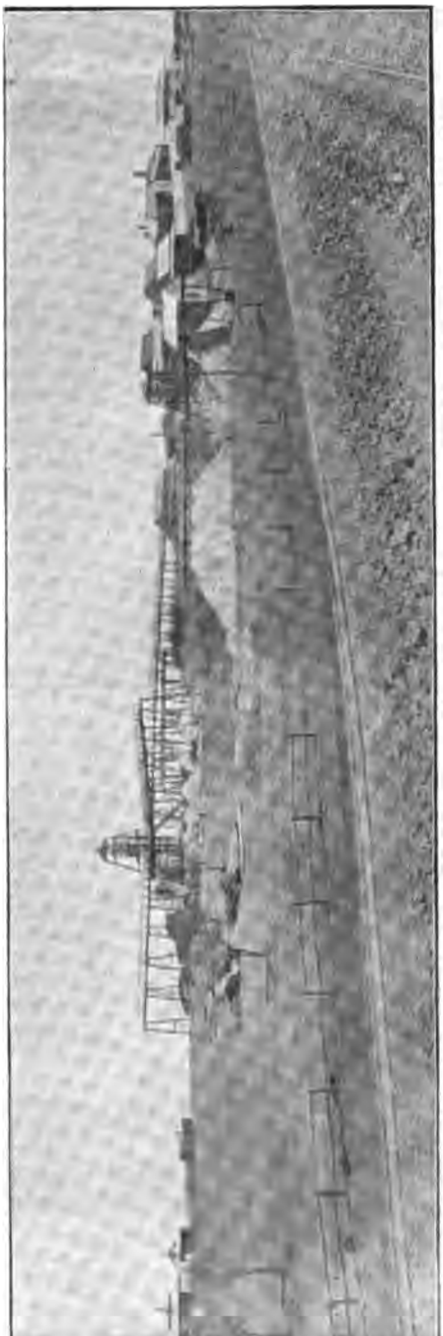

FIG. 3.—VIEW, FROM THE GREAT BOULDER HILLSIDE, OF THE IVANHOE MINE, LOOKING WESTWARD.

to exist on neighbouring properties, such as the Hannan's Brown Hill, Lake View and Ivanhoe. Hope was revived, and a new era dawned. The batteries began to yield steady returns, and old-time miners had their eyes opened, and their established notions of what was ore considerably upset. Mining in this district began to assume importance as the output of gold steadily increased, and consequently a revival set in throughout the colony.

FIG. 4.—VIEW OF POPPET-LEGS, ETC., AT MAIN SHAFT OF THE LAKE VIEW CONSOLS MINE.

Then, as time went on, in the early part of 1896, another trumpet blast went forth to the world which heralded another era in local mining. Again the old quartz-miners had their notions upset. Certain stone was being thrown away as mullock which scientific mining engineers proved to be valuable ore, an ore of rare occurrence, hitherto only found in payable quantities in America and Transylvania. This was ore carrying telluride of gold. Would it be proved to exist in payable quantity or only as a deterrent associated mineral? The mineral was

first noted as occurring, associated with calcite, at the Block 45 mine, situated near the Hannan's Brown Hill mine. Subsequently it was found in other mines of the district, either disseminated finely through what was apparently country-rock, quite apart from the quartz-veins or reefs, or occurring in small splashes and veins in the stone. It was generally associated with iron-pyrites, and sometimes free gold was visible.

This occurrence, upon the proof of its prevalence in some of the adjacent mines, at once gave a certain distinction to the locality, and brought to it from afar, with special interest, many of the recognized world's authorities on scientific mining. Rapid developments ensued, and the gold output continued to increase.

FIG. 5.—VIEW OF MAIN SHAFT AND TAILINGS-DAM OF THE GREAT BOULDER PROPRIETARY MINE.

The township of Kalgoorlie soon became a city, and the huts of employees on the mines, together with those trading with them, multiplied so enormously on the leases, that a new township was laid out nearer the mines, now known as Great Boulder City. The railway was carried forward from Coolgardie, and it was evident that the good times had "come to stay."

The marvellous changes that have taken place in the district since then can hardly be realized by anyone who has not visited it. The accompanying views, however, will give evidence to strangers of what

has been done on the surface. As regards the actual work of mining, when the fact is taken into consideration that hundreds of shafts have been sunk to depths varying from 50 to 500 feet, and that many miles of driving and cross-cutting have been done therefrom, and, in the case of the bigger mines, immense bodies of ground have been stoped out; and when again the very potent fact is taken into consideration that the output of gold from this district alone is now over 30,000 ounces per month, even a total stranger can grasp some notion of the great progress that has been made. Probably by the end of the current year (1898) this monthly output will be increased to 50,000 ounces. Without taking into account alluvial gold, of which very many thousands of ounces have been won, but of which no register can be made, the total output from Kalgoorlie, up to March, 1898, has been 519,786 ounces. In the year 1891, the total output of gold for the colony, for the year, was somewhat less than the present output from Kalgoorlie alone for one month.

The bulk of the above-mentioned gold (of this district) has been won from free-milling ores, that is to say, ores wherein the gold is not combined with refractory minerals, but is free to amalgamate with quicksilver, or submit to the solvent properties of cyanide solutions as the case may be.

Refractory ores have up to the present time been all sent away to other colonies or to Great Britain or Europe for treatment, and have in many cases yielded high returns. Now, however, both at the Lake View Consols and the Australia mines (Associated Gold-mines of Western Australian Limited), extensive plants are in course of erection for the treatment of these ores, which prevail at the deeper levels now being attained. Other mines will, no doubt, follow suit.

At the Lake View Consols mine the tailings are profitably treated by cyanidation. The plant is a very extensive and well arranged one. At the Ivanhoe mine, a fine cyanide plant has been erected for a similar purpose (Fig. 3) While, at the Great Boulder mine, the treatment of an accumulation of some 50,000 tons of tailings will shortly commence (Fig. 5).

At the Australia and Hannan's Brown Hill mines, the ore is crushed dry in ball-mills and cyanided, and both plants have lately been much increased in capacity.

These measures, it may readily be perceived, will probably add considerably to the present output. Of the mines, the Great Boulder is probably best known to the general public. It at present holds pride of

place as regards output, but a keen spirit of emulation is abroad, and it is possible that within another year there may be a neck-and-neck contest between three or four of the first-class mines for leading figures in actual monthly output; though with its present good lead it will be some time before the Great Boulder mine can be surpassed in total output.

Up to March, 1898, the following figures are representative of the total outputs of the respective mines:—

Mines.	Gold in Ounces.
1. Great Boulder Proprietary	185,452
2. Lake View Consols	117,786
3. Ivanhoe	51,743
4. Australia	40,953
5. Hannan's Brown Hill	36,254
6. Great Boulder Perseverance	30,519

While Coolgardie can rightly claim to have afforded the motive power requisite for the colony's leap from obscurity, as regards gold-mining, to a sphere of prosperity, it is to Kalgoorlie that the credit is due of bringing her into the first rank with the gold-producers of Australasia. Indeed, Queensland will have to look to her laurels before long.*

Technically speaking, Kalgoorlie is at present the only district of its kind in Western Australia, but already it is rumoured that rivals are to appear. Kalgoorlie itself is as yet in its infancy. Who can say what the future may bring forth?

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* This prophesy has already come true; in 1898, the gold-production of Western Australia was 45 per cent. greater than that of Queensland, in spite of the fact that the production of the latter colony in that year showed a substantial increase over the preceding year.

THE MINING INSTITUTE OF SCOTLAND.

ANNUAL EXCURSION, AUGUST 10TH, 1899.

About 100 members, conveyed by train from different parts of the country, met at Hamilton, and were conveyed in brakes to the Bent Colliery Company's Hamilton Palace colliery.

HAMILTON PALACE COLLIERY.

A large area of coal-field is worked from one point, the workings extending 1½ miles from the pit-bottom. The two shafts, 24 feet by 8 feet, are sunk 582 feet to the Ell coal-seam. The shafts are deepened a further depth of 360 feet to level out the Splint coal-seam by a mine at the deepest part of the field.

The winding-engines at each pit have cylinders 26 inches in diameter by 5 feet stroke, the drums are 16 feet in diameter, with a groove turned in the cleading for the rope. The No. 1 pit winding-engine has Cornish valves and a steam- and hand-brake ; and the No. 2 pit winding-engine has slide-valves and a steam-reversing engine.

The compound pumping-engine has a high-pressure cylinder 28 inches in diameter, and a low-pressure cylinder 56 inches in diameter by 6 feet stroke, and is coupled direct to bell-cranks made of steel-plates.

Steam is produced by 4 batteries of Babcock & Wilcox water-tube boilers at a pressure of 100 pounds per square inch ; and 4 Lancashire boilers, 30 feet long by 8 feet in diameter, at 80 pounds pressure.

In No. 1 shaft there is a double set of plungers, 16 inches in diameter, forcing 462 feet. The water from the pit-bottom is being temporarily raised by a three-throw pump with plungers 7 inches in diameter by 18 inches stroke, double-acting, driven by an electric motor of 30 horse-power. The pump-rods at the pit-mouth are jointed and guided between rollers, so as to keep them plumb in the shaft.

The Guibal fan, 30 feet in diameter by 8 feet wide, at 48 revolutions per minute, produces 120,000 cubic feet of air-current per minute. No. 2 pit, the upcast, is enclosed with brickwork at the pit-top, with a tunnel under the railway to the fan.

The screening-plant consists of 3 sets of screens (a fourth is about to be added), with slow-motion picking-bands and jiggers. Picking is also done on the delivery-jiggers, which are set at an angle of 1 in 8 for this purpose.

The pithead-frame at No. 1 pit is built of channel iron and lattice-work, and that at No. 2 pit of railway rails. The pulleys are 16 feet in diameter, the same diameter as the drums.

The electric plant consists of a 120 horse-power dynamo for power plant, driven by a compound condensing-engine, with a high-pressure cylinder 16 inches in diameter and a low-pressure cylinder 30 inches in diameter, by 2½ feet stroke, and a rope drive. A lighting dynamo for 400 16-candle lamps is driven by an engine with a cylinder 10 inches in diameter by 16 inches stroke.

The air-compressing plant consists of a pair of steam and air cylinders—the former 20 inches in diameter, one of the latter 20 inches, and the other 22 inches in diameter, by 3½ feet stroke. The air is delivered into the receiver at a pressure of 60 pounds per square inch, and taken down the pit in malleable iron pipes, 8 inches in diameter.

The haulage-engine, on the surface, has two cylinders 12 inches in diameter, and drives a band-rope down the shaft, where it gives motion to an upright shaft with 3 haulage-pulleys, which haul the coal from distances of 3,000, 3,600 and 3,600 feet respectively.

The underground haulage-machinery consists of an electric plant driven by a 60 horsepower motor. At present there are 2 haulage-planes (machinery fitted for three) working at distances of 3,000 and 4,200 feet respectively, with gradients against the load. This plant is placed 3,300 feet from the pit-bottom. All the above haulages are worked by endless-ropes (Plate I.).

There are three tail-rope haulage-planes, with engines, 12 inches cylinder by 3 feet stroke, 12 inches cylinder by 2 feet 9 inches stroke, and coupled 8 inches cylinders by 18 inches stroke respectively, drawing coal from distances of 1,200, 1,500 and 3,900 feet respectively; and a single-rope haulage, with an engine with coupled 9 inches cylinders by 2 feet stroke, drawing up a dook 400 yards long (Plate I.). All of these engines are driven by compressed-air.

There are 18 pumping-engines underground, mostly small Worthington and Duplex engines, forcing water out of depressions, and all of them are driven by compressed-air.

The offices consist of counting-house, store, joiners' shop, smithy, engineers' shop, air-compressor and electric-plant houses, lamp-room, etc., fitted with appropriate machinery.

There are 295 houses for workmen, those most recently built being of unpointed brickwork, roughcast with cement and ground granite.

The output from No. 1 pit averages 1,000 tons per day.

From the bottom of No. 2 pit, at a depth of 942 feet, two mines are being driven, to distances of about 4,200 and 5,400 feet respectively, to the Main and Splint coal-seams in the lowest part of the coal-field. A Hirnant drilling machine, driven by compressed-air, is provided for boring holes in any specially hard materials met with.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,
HELD IN THE RECREATION ROOM, HAMILTON PALACE COLLIERY,
AUGUST 10TH, 1899.

MR. JAMES T. FORGIE, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen were elected:—

MEMBERS—

Mr. J. F. BALFOUR, Lebong Donok, Benkoelen, Sumatra.
Mr. JOHN DALZIEL, 5, Parkhead Street, Motherwell.
Mr. DAVID MURDOCH, Ayr Colliery, Annbank.
Mr. JOHN H. STEWART, Ramsay's Buildings, Hamilton.
Mr. DAVID SUTTIE, Labuan Collieries, Labuan, Borneo.

ASSOCIATE MEMBER—

Mr. J. BERNARD LEAN, Whitelaw, Bothwell.

ASSOCIATE—

Mr. DAVID WALKINSHAW, Newton Colliery, Newton.

DISCUSSION OF MR. ROBERT WEIR'S PAPER ON "THE DOUGLAS COAL-FIELD, LANARKSHIRE."*

Mr. R. W. DRON wrote asking Mr. Weir how he arrived at the estimate of 15,000,000 tons of workable coal. The area of the estate containing the coal-seams shown on Mr. Weir's plan is about 700 acres. From the Gill to the Fallowhill coal-seam, the section shows over 60 feet of coal. Taking 700 acres of coal, 60 feet thick, gives a maximum tonnage of fully 60,000,000, and deducting one-third for loss, etc., leaves a net quantity of 40,000,000 tons. Does Mr. Weir not think that, by the time 15,000,000 tons are worked, a considerable portion of the remaining

* *Trans. Inst. M.E.*, vol. xvi., page 436, and vol. xvii., page 170.

25,000,000 tons will be considered workable—although possibly not all workable at the present time?

It would be interesting if Mr. Weir could give some details of the bore-hole near Douglas station, whose depth was about 1,278 feet. At this depth, the Limestone Measures should be found, and the assumption is that the thinning out referred to as occurring to the dip of Rigside colliery has continued, and that in the centre of the basin all the coal-seams are thin. The Limestone Measures on Brockencross Moor to the north-west of the Lanark railway have been bored at several points, and the coal-seams found are much thinner than either the Rigside or the Coalburn section.

In the Kennox Water, bore-holes have been put down, but without much success. Bore-holes have also been put down at Bellishole and Crowhill with similar results.

The writer of *Explanation of Sheet 23** of the maps of the Geological Survey describes this coal-field as having been formed in a hollow or water basin. If this description be correct, then, during the formation of the coal-seams the centre of this basin would seldom become dry, so that, although thick seams were formed on the margin, the conditions in the centre would not be so favourable for the deposition of coal. This circumstance should always be borne in mind when estimating the probability of coal being found in the Limestone Measures underneath newer formations, and in the present case may account for the thinning out of the coal-seams in the centre of the basin.

The further discussion was adjourned.

The following "Notes on Hamilton Palace Colliery" were read by Mr. J. S. Dixon:—

* Page 22.

NOTES ON HAMILTON PALACE COLLIERY.

By JAMES S. DIXON.

This coal-field is certainly the largest in Lanarkshire, if not in Scotland, worked from two pits at one site, consisting as it does of nearly 900 acres. The field is in the form of an irregular parallelogram about $1\frac{3}{4}$ miles long by $\frac{3}{4}$ mile wide (Fig. 1, Plate I.). The workings stretch from the pits about $1\frac{1}{2}$ miles in a south-easterly and about $\frac{3}{4}$ mile in a westerly direction.

It is fitted with two shafts, each 24 by 8 feet, the Ell coal-seam being got at a depth of 582 feet, but the shafts have lately been sunk a further depth of 360 feet, from which mines are being driven to level out the Main and Splint coal-seams near the centre, and in the latter case at the deepest part of the field.

A pair of parallel places, *AC* (Fig. 1, Plate I.; and Fig. 2, Plate II.), each about 12 feet wide, have been driven right along the centre of the field, and they as nearly as possible bisect it. From these, branch roads have been driven to the various sections. The two parallel roads referred to form the main arteries for the traffic from and to the pit-bottom, the empty hutches going in by one and the full ones coming out by the other, with a double road in each.

The field has proved a rather troubled one. At a distance of only 600 feet from the pits, a fault was encountered which proved to be an upthrow to the south of between 300 and 360 feet. This was cut by a pair of mines, each 2,100 feet long, rising about 1 in 32. At a distance of only 240 feet from the termination of these mines, a downthrow fault of about 60 feet was met with ; this was cut by a steep mine of 1 in 4, and after the coal inside had been sufficiently proved it was levelled out by a mine driven partly in the Pyotshaw coal-seam. At a farther distance of 1,500 feet a 42 feet downthrow fault was met, and 360 feet from this an upthrow fault of about 150 feet was got throwing the Splint coal-seam opposite to the Ell coal-seam. After mining a distance of about 1,200 feet in the Splint seam, a downthrow fault threw the Ell coal-seam 30 feet under the Splint, making a dislocation of about 180 feet. This was cut in the same manner as stated above, and afterwards levelled out by a mine 900 feet long. This mine was driven

simultaneously from both ends, and was a good example of careful surveying, as it met in the centre perfectly accurately both as regards direction and gradient.

In addition to the main roads, which bisect the field, these dislocations and others have had to be cut by long mines in different directions. Mining engineers do not require to be informed that these operations caused much anxious consideration first in proving, next in exploring, and then in cutting permanent roads to make suitable haulage-roads. The steepest gradient is 1 in 8 against the load for a short distance near the electric-hauling station.

The 150 and 180 feet dislocations referred to present a somewhat extraordinary phenomenon. The area, *G H*, enclosed by these slips is fish-shaped, about 4,800 feet long by about 600 feet wide at its broadest part, decreasing towards its extremities, and thus forming an underground hill with cliffs on either side about 150 and 180 feet deep, with a plateau on its top of about 45 acres in area.

The Ell coal-seam, from 6 to 7 feet in thickness, is worked on the stoop-and-room system. The stoops are generally formed 90 feet by 60 feet and the places are 10 feet wide. Where the roof is bad in the easternmost section the head coal is left as a roof in the first working, and afterwards all is removed, and in part of that area the stoops are now being left double the size stated above, as the roof is soft.

Some small areas of the Main coal-seam have been worked on the longwall system, and the Splint coal-seam, where mined through as before described, is being worked on the stoop-and-room system, very large stoops being left.

Engines on the surface haul the coal for distances of 3,600, 3,000 and 3,600 feet respectively. The 3,000 feet road was formerly about 4,500 feet in length. The electric-driven plant underground hauls distances of 4,200 and 3,000 feet, and when a mine now being driven is completed another haulage-road about 3,600 feet long will be added. Tail-rope engines underground haul distances of 3,900, 1,500 and 1,200 feet respectively, and a single rope hauls 1,200 feet.

The quantity of water in the mine is only about 250 gallons per minute, but as the workings first rise and then dip in all directions, some 18 small pumps are employed in raising water from the declivities, and some water is conducted through the hollows by pipes forming inverted syphons. The lowest point in the workings is 185 feet under the level of the pit-bottom.

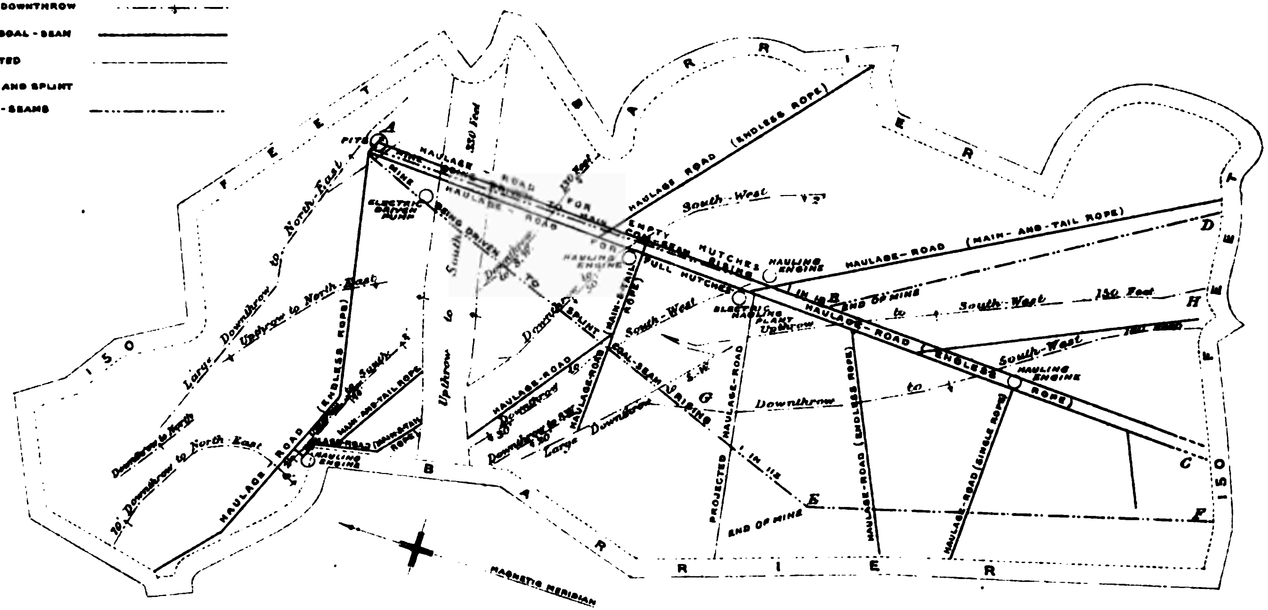
The development of the workings was greatly hindered by the

To illustrate Mr James S. Dixon's "Notes on Hamilton Palace Colliery."

FIG. 1.

REFERENCES.

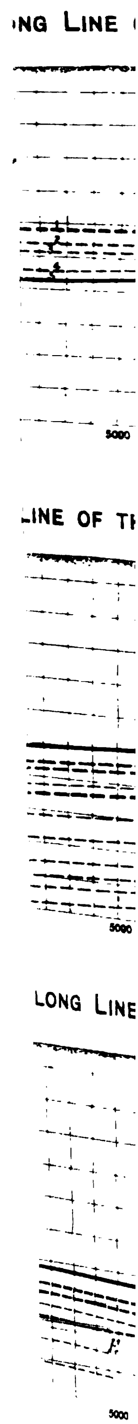
FAULTS
" DIRECTION OF DOWNTHROW
HAULAGE ROADS IN ELL COAL-SEAM
" " PROJECTED
" " IN MAIN AND SPLINT
COAL-SEAMS



Scale, 1,760 Feet to 1 Inch.

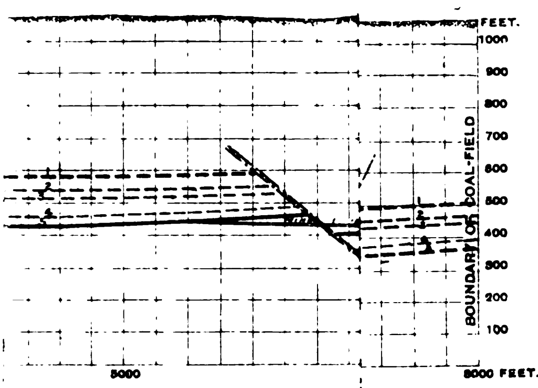
Andw Reid & Compy Ld Newcastle-on-Tyne

Notes o



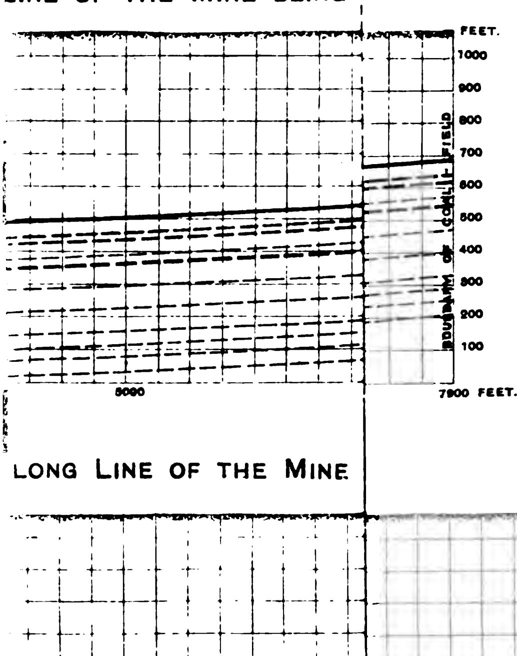
Notes on Hamilton P

ING LINE OF THE ROAD, 1



Scale, 600 Feet to 1 Inch.

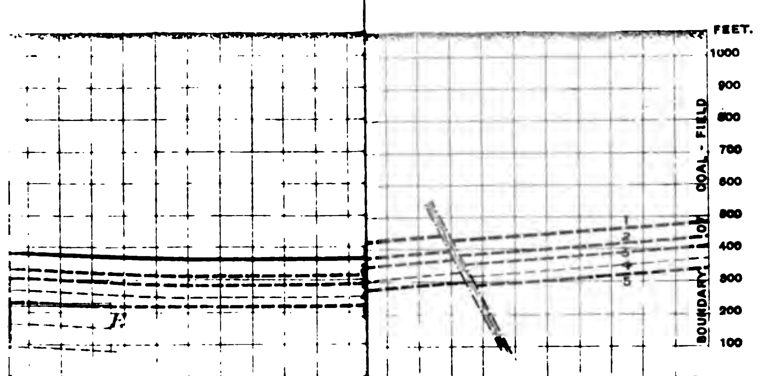
LINE OF THE MINE BEING



REFERENCES.

1.—ELL COAL-SEAM.
2.—PYOTSHAW COAL-SEAM.
3.—MAIN COAL-SEAM.
4.—HUMPH COAL-SEAM.
5.—SPLINT COAL-SEAM.
6.—BLACKBAND IRONSTONE-SEAM.
7.—VIRTUEWELL COAL-SEAM.
8.—MUSSELBAND IRONSTONE-SEAM.
9.—KILTONGUE COAL-SEAM.
10.—UPPER DRUMGRAY COAL-SEAM.
11.—LOWER DRUMGRAY COAL-SEAM.

LONG LINE OF THE MINE



intervention of the numerous troubles referred to and the mines that had to be driven. But this was to some extent overcome by the introduction of Stanley heading-machines driven by compressed air, with which some miles of headings were driven at about four times the speed of hand labour. A paper on the working of these machines contributed by the writer is printed in the *Transactions.**

As already stated, the pits have been sunk to a depth of 942 feet, from which mines, *A B* (Fig. 3, Plate II.) and *A E* (Fig. 4, Plate II.) are being driven to cut the Main coal-seam at a distance of 4,200 feet, and the Splint coal-seam at a distance of 5,400 feet, respectively.

The former mine is being driven at a rising gradient of 1 in 18, through which it is proposed to haul the coal by a self-acting arrangement. The latter is being driven at a gradient of 1 in 113 to be hauled by electric power, and through this mine the water from all the seams above the Splint coal-seam, in the greater part of the field, will flow to the pit-bottom.

It is expected that the positions of all the seams down to the Lower Drumgray will be cut in driving these mines, which are intended to open out and develop the Pyotshaw, Main and Splint coal-seams in the different sections of the field. Another long mine may be driven to the Splint coal-seam in the western part of the coal-field.

At present only No. 1 pit is drawing coals: it is fitted with a single-deck cage with two hutches containing about 14 cwts. each. The output averages 1,000 tons per day of 9 hours, the record being 1,161 tons in that time. The output for the last three months was 72,865 tons or at the rate, including holidays, of about 290,000 tons per annum from a single shaft in an ordinary winding shift. An equal output is expected from No. 2 pit, when the mines are completed and the coal workings developed.

DISCUSSION OF MR. G. L. KERR'S PAPER ON "TIMBERING AND SUPPORTING UNDERGROUND WORKINGS."†

Mr. R. W. Dron wrote that Mr. Kerr took exception to the statement by Prof. Louis that "the strength of a pit-prop is practically independent of its length, within ordinary limits."‡ Prof. Louis' statement is quite correct in cases where the length does not exceed

* *Trans. Inst. M.E.*, 1893, vol. vi., page 4.

† *Ibid.*, vol. xvi., pages 230 and 430; and vol. xvii., page 168.

‡ *Ibid.*, vol. xv., page 352.

10 times the diameter. The statement that "the strength of pillars of timber is inversely proportional to the square of the length"* has been deduced by Euler from elaborate theoretical researches; but Dr. Hodgkinson's practical experiments gave the rule that the strength is inversely proportional to the 1·63 power of the length. In any case neither of those rules applies to pit-props, as they are based on the assumption that the length is at least 15 times the diameter with round ends and 30 times the diameter with flat ends. For instance, if using an 8 feet prop by 3 inches in diameter this rule would be applicable; but comparing an 8 feet prop by 10 inches in diameter with a 2 feet prop by 10 inches in diameter we are safe enough to adopt Prof. Louis' rule. Certainly, the 2 feet prop has not 16 times the strength of the 8 feet prop.

There is one point about the use of timber to which more attention should be called. He (Mr. Dron) advised that timber should not be used to support a weight of loose material unless under exceptional circumstances. Timber should be chiefly used to prevent a roof from beginning to break. It is much more easy to keep a bad roof from commencing to come down than it is to support the roof after it shows signs of giving way. Regular and systematic timbering for this reason should prove not only safer, but also more economical, than the practice, so often adopted in Scotland, of putting in timber only when the roof begins to sound "heavy."

The further discussion was adjourned.

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* *Trans. Inst. M.E.*, vol. xvi., page 243.

MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,

HELD AT THE QUEEN'S HOTEL, LEEDS, ON AUGUST 1ST, 1899.

MR. W. H. CHAMBERS, PRESIDENT, IN THE CHAIR.

The minutes of the previous General Meeting were read and confirmed.

Messrs. J. L. Routledge and R. Routledge were appointed scrutineers of the balloting papers for the election of officers for 1899-1900, and of the balloting papers for representatives on the Council of The Institution of Mining Engineers for 1899-1900.

The following gentlemen were elected, having been previously nominated:—

MEMBERS –

Mr. ELLIS BARRACLOUGH, Colliery Manager, Ackton Hall Colliery, Featherstone, Pontefract.

Mr. WILLIAM WENTWORTH CLARKE, Colliery Manager, Lidgett Colliery, Barnsley.

Mr. JOHN WILLIAM GARSIDE, Electrical Engineer, Brookhouse Cottage, Brighouse.

Mr. RALPH RICHARDSON, Mining Engineer, Barrow Collieries, Barnsley.

The Annual Report of the Council and the statement of accounts for the past year were read as follows :—

THE COUNCIL'S ANNUAL REPORT.

The Council have pleasure in presenting to the members of the Institute their report on the work of the past year.

The number of members for the past two years is as follows:—

	1897-98.	1898-99.
Life Members	4	4
Honorary Members... ...	11	11
Members	228	226
Associate Members ...	9	7
Associates	17	15
Students	12	11
Totals ...	281	274

If all the members had duly paid their subscriptions there would have been an increase in all classes during the year of 11.

Of the £36 of arrears of subscriptions for 1897-98, £10 10s. have been collected during the past year. There is, however, a balance of £25 10s., which has now been written off as irrecoverable.

The Council again regret to have to state that there has been, during the past year, considerable irregularity in the payment of subscriptions, the arrears amounting to £27 from 18 members. This deficiency does not appear in the balance-sheet, as only the names of those members who have paid their subscriptions are returned to the Secretary of The Institution of Mining Engineers.

The following papers have been read during the past year:—

"Presidential Address." By Mr. W. H. Chambers.

"The Whitwick Colliery Disaster." By Mr. J. Ford.

"The Rhenish-Westphalian Coal Syndicate." By Mr. G. Blake Walker.

A very successful meeting has been held in conjunction with the Chesterfield and Midland Counties Institution of Engineers, at which the following papers were read and discussed:—

"The Use and Abuse of Colliery Locomotives." By Mr. W. W. Clayton.

"The Safety of Modern Mining Explosives, with Special Reference to Methods of Testing." By Mr. L. T. O'Shea.

"The Application of Carbonic Acid to Gob-fires." By Mr. George Spencer.

The Council regret to have to record the death of two highly-esteemed members of the Institute, namely:—Mr. A M. Chambers, a Past-President of this Institute, and President of The Institution of Mining Engineers at the time of his death; and of Mr. Geo. J. Kell, a former Vice-President, who for many years took an active part in the work of the Institute.

MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.

GENERAL STATEMENT, 1898-99.

LIABILITIES.

1899.		£	s.	d.
June 30.—None.				
„	To Balance, being capital	440	9	2½
		£440	9	2½

ASSETS.

1899.		£	s.	d.	£	s.	d.
June 30.—By Cash in Bank		85	11	11			
„ „ „	Treasurer's hands ...	1	19	3½			
					87	11	2½
„ „	Value of 6,779 parts of *Transactions*, at 1s. ...	338	19	0			
„ „	Value of 115 Copies of Narratives of Sudden Outbursts of Gas, at 1s.	5	15	0			
„ „	Value of 116 Copies of Committee's Report on Safety-lamps, at 1s.	5	16	0			
„ „	Value of 16 Copies of Report of French Commission on Use of Explosives, at 3s. ...	2	8	0			
					352	18	0
					£440	9	2½

Examined and found correct,

H. B. NASH,
E. W. THIRKELL,
AUDITORS.

July 18*th*, 1899.

DR. THE TREASURER (MR. T. W. H. MITCHELL) IN ACCOUNT

MECHANICAL

	£ s. d.	£ s. d.
July 1st, 1898.		
To Balance at Bankers	86 17 0	
„ Cash in Treasurer's hands	5 1 9	
		91 18 9
June 30th, 1899.		
To Subscriptions for 1898–99...	375 0 0	
„ „ paid in advance for 1899–1900	5 18 7	
„ Arrears	10 10 0	
		391 8 7
„ Sale of Dinner Tickets	9 12 6	
„ Members' portion of the Wine Account at the Annual Dinner	4 10 0	
		14 2 6
„ Sale of *Transactions*		2 7 0
„ Letting of Room		1 17 6
„ Chesterfield and Midland Counties Institution of Engineers—Moiety of Expenses of Joint Meeting ...		3 0 11
„ Bank Interest		4 0 2
		£508 15 5

Examined and found correct,

H. B. NASH,

E. W. THIRKELL,

AUDITORS.

July 18th, 1899.

WITH THE MIDLAND INSTITUTE OF MINING, CIVIL AND ENGINEERS, 1898–99. CR.

	£ s. d.	£ s. d.
June 30th, 1899.		
By The Institution of Mining Engineers:—		
Call of 19s. per Member on 260 Members for 1898-99	247 0 0	
„ Balance of Call for 1897-98	7 12 0	
„ Excerpt *Transactions*, etc.	3 1 0	
„ Proportion of cost of Exchanging *Transactions* with other Societies (2 years)	6 6 8	
		263 19 8
„ Annual Dinner		25 1 3
„ Printing and Stationery		13 19 9
„ Rent of Room		12 0 0
„ Reporter		7 0 0
„ Insurance		1 11 6
„ Cleaning		0 3 0
„ Gas Company		0 6 4
„ Hire of Rooms for Meetings in Barnsley, Leeds, and Sheffield ...		3 9 0
„ Secretary's Salary	£50 0 0	
„ „ Expenses	13 5 2	
		63 5 2
„ Ordnance Plans and Cartoons		16 14 1
„ Stamps, Telegrams, Carriage, Wrappers, and Sundries		13 14 5½
„ Balance at Bankers	£85 11 11	
„ Cash in Treasurer's hands	1 19 3½	
		87 11 2½
		£508 15 5

The Council have had under their consideration the great importance of establishing stations for the saving of life and the recovery of mines after explosions in various centres of the Yorkshire coal-field. They consider this a matter in which this Institute can render valuable services, and it has been placed in the hands of a committee, whose report will be considered at the annual meeting. The Council consider it very desirable that the best-known appliances should be available for entering mines as soon as possible after an explosion takes place, and by means of the pneumataphore and similar apparatus, and of trained corps of explorers, they are of opinion that much may be done to save life and property. The Council trust that each individual member will take an interest in this scheme, and endeavour to enable the recommendations of the Council to be carried into effect by securing the financial co-operation of the collieries with which he is connected.

The committee formed to carry out the correlation of the Lancashire and Yorkshire coal-fields have not been able to proceed with this work during the past year. A difficulty in settling the lines on which the work should be done has occurred with the Manchester Geological Society, but it is intended to have a discussion on the question at the next joint meeting with that society, after which it is hoped that the matter can be proceeded with.

Mr. H. B. Nash remarked that the expenditure for the year had exceeded the income by £4 7s. 7d., showing that, if they were to maintain their position, they must, if possible, have more members. He proposed that the Report and Accounts be adopted.

Mr. E. W. Thirkell seconded the motion, which was agreed to.

Prof. E. H. Liveing read the following paper on "Underground Surveys and their Connexion with the Surface by the Transit Method":—

UNDERGROUND SURVEYS AND THEIR CONNEXION WITH THE SURFACE BY THE TRANSIT METHOD.

By Prof. E. H. LIVEING.

In these days of large royalties and extensive colliery-workings, the importance of accurate underground surveys becomes more and more evident. It is now generally recognized that careful theodolite surveys can alone be relied upon for all important work, and not only must these surveys be correct in themselves, but the connexion between the surface and the underground workings must also be correctly made, or the whole underground survey may be shifted in azimuth, and cause serious error and possible encroachments when the workings reach long distances from the shafts. For exact work, the use of the magnetic needle for this purpose is out of the question.

Where an adit-level exists, or even an inclined shaft, the theodolite survey may sometimes be carried straight into the mine, extra care being taken on inclines that the azimuth axis of the instrument is truly vertical, and that the adjustments as to squareness of the axes and collimation are perfect.

Where a mine has two vertical shafts at a considerable distance apart with workings communicating, the connexion is easily effected by making careful surveys between the centre lines of the two shafts, both at the surface and underground; each survey can then be plotted and superposed with the centres of the shafts coincident on plan, or both surveys may be plotted by co-ordinates, the difference of azimuth between the first sets of each survey having been determined by calculation.*

Unfortunately the shafts in collieries are often too near together to admit of this method giving satisfactory results, and in such cases either the plumb-line method or the transit method must be resorted to.

* Thus, calling the shafts A and B (Fig. 1, Plate III.), and taking A Z, the first set of the surface-survey, as a meridian, the latitude and departure of the point B are calculated: Dep. ÷ Lat. = tan Z A B, and angle Z A B is found. Again, taking A X, the first set of the underground survey, as a temporary meridian, the latitude and departure of B are also calculated: Dep. ÷ Lat. = tan X A B, and angle X A B is found. Now that angles Z A B and X A B are known, the azimuth angle Z A X in this case will equal their difference.

The plumb-line method is most suitable for comparatively shallow shafts of considerable diameter. It is largely used in railway-tunnelling. It consists in hanging two heavy plumb-bobs by wires in one of the shafts, as far apart as the width of the shaft will permit. The plane in which these plumb-lines hang is taken as the common meridian from which to start both surface and underground surveys. With deep shafts, however, difficulty is experienced in bringing the plumb-lines to rest; even though the plumb-bobs are immersed in buckets of water, oil or tar, it is found that in coal-pits the currents of air in the shaft keep them in motion, or at least prevent them from assuming an absolutely vertical position.

For deep shafts therefore, and for great accuracy, the transit method alone remains. This method was originally proposed and successfully employed for many years by the late Mr. A. Beanlands, of Durham, who contributed a paper on the subject, which will be found in one of the early volumes of the North of England Institute of Mining and Mechanical Engineers.* The writer hopes, however, that the following particulars, the result of his own experience of Mr. Beanland's method during the past 22 years, may be of use to the members.

A transit instrument consists of a sighted telescope having a single axis at right angles to its line of sight, this axis terminates in 2 equal cylinders or trunnions, which are carried in Y-shaped bearings attached to iron or masonry supports.

The transit is the most important instrument of the astronomer, and is employed in observatories to determine the exact time of the meridian passage of stars and other celestial objects. For this purpose the telescope is often large, having an object glass of 6 and even 8 inches aperture, and the Y-bearings are carried on solid masonry piers; but for surveying purposes a much smaller instrument is employed, one of 2¼ to 2½ inches aperture and from 30 to 35 inches focus being a convenient size (Fig. 5). This is used with a portable iron stand having levelling screws and a horizontal screw adjustment to one of the Y-bearings. For shaft-work, the base of the stand should be open, so as to allow of the telescope being pointed down the shaft. The instrument is commonly provided with a long striding level, the legs of which rest upon the trunnions in order to adjust the axis truly horizontal. The level is, however, sometimes hung by small studs parallel to the main axis as shown in the illustration (Fig. 5). There is also a graduated circle with vernier plate and level to determine the altitude of any

* *Trans.*, vol. xx., page 85.

object observed with the telescope. The eyepiece end of the telescope is provided with a wire frame, carrying for astronomical purposes 5 vertical wires and 1 horizontal wire. For shaft work, however, 1 vertical wire and 1 horizontal wire will suffice; these should be spider lines, but not

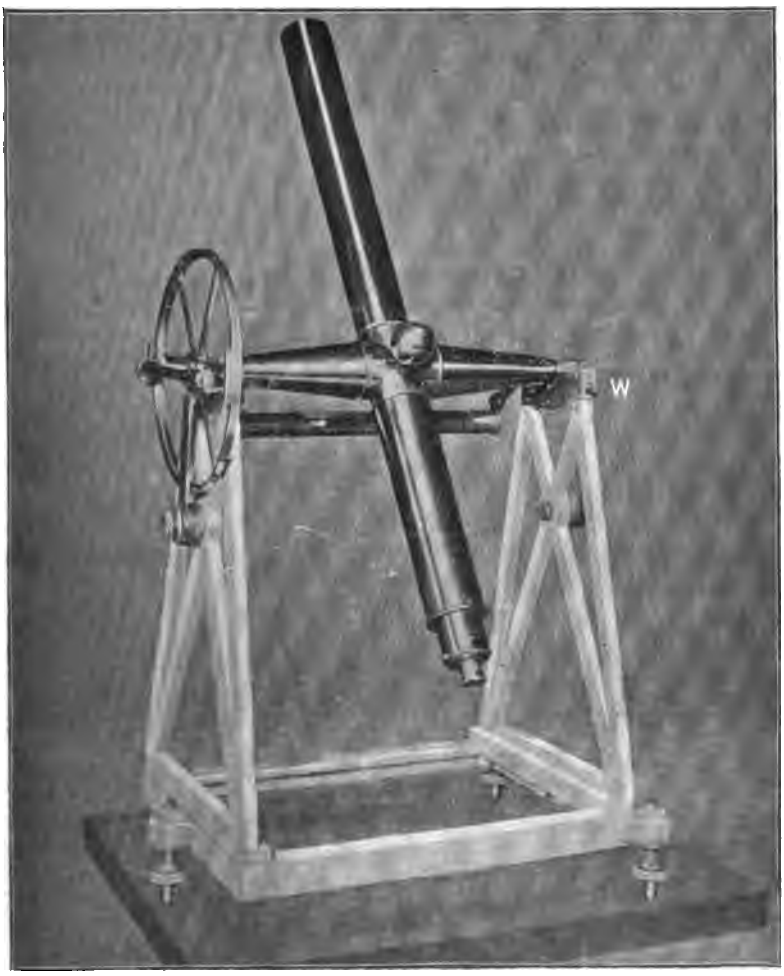


FIG. 5.—TRANSIT INSTRUMENT.

too fine. One of the trunnions of the instrument is perforated and a diaphragm mirror, within the telescope, illuminates the wires when a lamp is placed at the end of the axis.

The wire-frame is held by two opposing adjustment-screws and the

collimation-adjustment is made in the same manner as with the transit-theodolite, namely, by bisecting some distant object, then reversing the instrument in its Y-bearings and correcting half of any error by the wire-plate screws. The line of sight will then be exactly at right angles to the axis of motion and, if the axis be level, the line of sight describes a truly vertical plane, as the telescope is turned on its axis, and this plane takes the place of the plane of the plumb-line in the last-mentioned method.

The use of the transit-instrument, with its axis horizontal, to connect surface and underground surveys depends on the fact that any two horizontal or inclined lines in a truly vertical plane have the same bearing in plan, in fact are either coincident or form a continuation of the same straight line.

The use of the transit-instrument for the same purpose with its axis not truly horizontal depends on the fact that any two horizontal lines in an inclined plane have the same bearings in plan, they are in this case parallel, but not coincident or a continuation of one another.

The connexion observation is generally best made in the downcast shaft, because the air is there clear and has a fairly uniform temperature, which is a matter of great importance as avoiding irregular refraction.

As the pit must be "off work" while the observation is being made, it is usually best to choose Saturday afternoon or Sunday for the purpose.

To fix the transit-instrument, two heavy balks of timber are placed across the mouth of the shaft, preferably at the ground-level and not on the top of the heapstead, on account of possible flexure and vibration. On these balks the transit stand is supported, a light and quite independent staging of boards being fixed a little above the balks to carry the observer, without fear of vibration to the instrument.

At the shaft-bottom, two short battens, A and B (Fig. 2, Plate III.), are nailed across the shaft-framing, about 4 feet above the flat sheets, and upon these is fixed a horizontal bar of pine, 6 by 3 inches in section; the middle point of this bar should be placed perpendicularly below the centre point of the transit-instrument, and the bar should be placed in the direction of the main road from the shaft-bottom.

Upon this bar, at equal distances from the centre points, are screwed two small wooden boxes of the construction shown in Figs. 3 and 4 (Plate III.), the top of each box is inclined at an angle of 45 degrees and is perforated, and two fine copper wires, E, stretched diagonally across a

small brass frame, are secured to this opening. The thickness of these wires must vary with the depth of the shaft and power of the telescope employed. Thus, with a 2¼ inches aperture, wires of No. 20 B.W.G., about 0·035 inch thick, answer well for pits not exceeding 600 feet deep, but for greater depths the thickness of the wire must be increased in proportion. In the lower part of the box is fixed a mirror, D, inclined at an angle of 45 degrees, and this reflects, in an upward direction, the light of a lamp placed opposite an opening, C, in the side of the box. A piece of ground glass should be placed between the lamp and the mirror, so as to produce a more uniform illumination. These two boxes, with their cross wires, are fixed upon the bar as far apart as the width of the shaft will permit, and this is seldom more than the length of the cage, from 5 to 10 feet.

A well-adjusted theodolite, having a centering stand, is set up about 20 to 30 feet distant from the cross wires, and as nearly as may be in a line with them; the wires are illuminated by a screened lamp placed behind them, and the theodolite is moved on the centering plates until both cross wires come into an exact line with the cross hairs in the telescope as they are brought alternately into correct focus. The theodolite is then firmly clamped in this position; and this line of sight, which will be the base-line of all future underground surveys, is carefully pegged out as far as possible along the main road, hooks in the roof and plugs in the thill being employed at each station to secure the points, and at least three points should be taken, so that if one be lost the direction is still retained, and also so that, if any lateral shifting of the strata occurs, it is detected by the three points being no longer in a straight line.

This work being complete, the theodolite is left in position while the surface observation is being made. Two lamps are placed opposite the reflectors of the boxes, so that the cross wires are illuminated when viewed from the surface. The observer now ascends the upcast shaft or other second exit from the mine.

The transit-instrument, with its axis level and previously focussed carefully for a distance equal to the depth of the shaft, is pointed down the shaft and the illuminated cross wires alternately observed, the axis of the instrument being moved in azimuth by the Y screw (W) until both the crosses are absolutely bisected by the cross hairs of the telescope, as it is turned from one to the other: the telescope is now turned to a horizontal position, and if a good long sight can be obtained along the surface of the ground it is pegged out. The writer has found

that this bisection observation should be repeated at least 6 times, the instrument being shifted slightly in azimuth between each observation and then brought back to the truth, and the observer should stand alternately on either side of the telescope. Any variation in the position of the horizontal sights obtained should be noted by pencil lines on a distant board, and the average position taken as the true direction. This line being determined, at least three permanent plugs should be put in coincident with this line which will form the base-line for all surface-surveys.

It frequently happens that, around the shaft-mouth, there exist buildings or other obstructions preventing the direct line of sight of the transit from being simply pegged out upon the surface, and in this case an angle must be taken with a theodolite. The transit telescope is placed horizontal and the eyepiece being removed the cross hairs are illuminated by a lamp, having a ground-glass screen placed near the eyepiece-tube. The theodolite is then set up level with and as nearly as possible in a line with the transit telescope and from 10 to 20 feet distant from it, the telescopes being pointed with the object-glasses towards each other. On focussing the theodolite, the cross hairs of the transit-telescope should become visible, and on turning the theodolite slightly on its axes, the cross hairs of both telescopes are made to bisect each other exactly. This being the case, the lines of sight of the two instruments are parallel, though not necessarily exactly coincident, but as the transit telescope (focussed for distant objects) acts as a collimator, a little lateral error in placing the theodolite will not cause any material change in the direction of the back sight or alter to any serious extent the angle to be read. Therefore, having taken a back sight from the transit line the theodolite is turned in some direction where a distant sight can be obtained which is then pegged off upon the surface. The angle between it and the transit-line is carefully noted each time that the bisection observation is made, and an average of the observed angles is taken as the true one. They should not differ from one another more than about 1 or 1½ minutes. A peg is also put in where the theodolite stands, and its distance from the transit-centre is noted, and this completes the connexion. The observer returns once more to the shaft-bottom and observes that no shifting has occurred in the direction of the cross wires while he was making the surface observations.

The writer had occasion recently to make the connexion observation in a pit 1,500 feet deep, in which the cross wires could not be placed more than 8 feet apart; in this case he replaced the cross wires by

To illustrate Prof. E. H. Liveing's Paper on "Underground Surveys" etc.

Fig. 1.

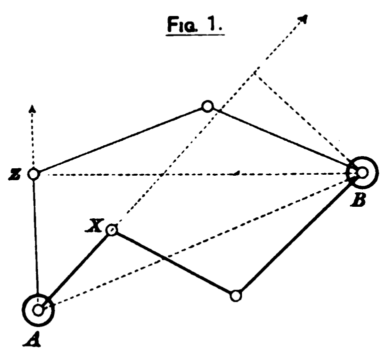


Fig. 2.

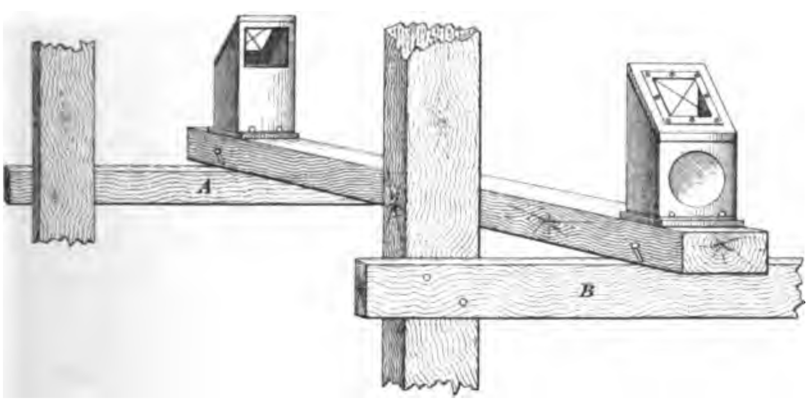


Fig. 3.

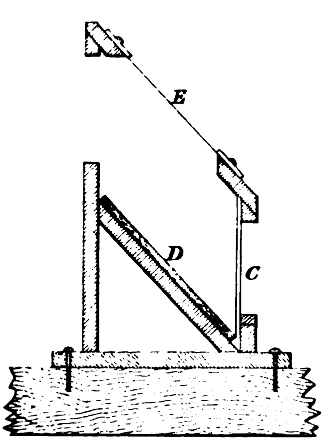
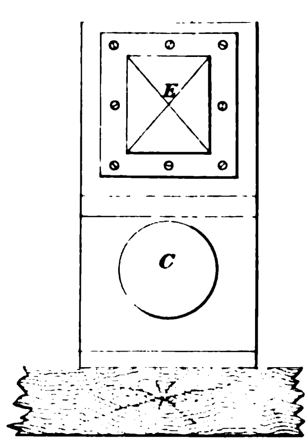


Fig. 4.



Andw Reid & Company Ltd [illegible]

two small electric lamps, each having small arched filaments. The lamps were fixed so that the planes of the filament were in the vertical plane joining them; the axes of the lamps, however, were inclined at an angle of about 45 degrees, in order that the filament could be viewed both vertically and horizontally through the spherical part of the globe. This plan was found to facilitate greatly the bisection observation, and can be recommended for deep shafts; but the lamps must be small and the filaments central in the globes, else irregular refraction of the glass might cause a slight error in the result.

It happens sometimes, though rarely, that the transit-instrument has to be used with its axis not truly horizontal. In this case the lines of sight both at the surface and underground must be kept horizontal, so that they may have the same bearings on the plan.

The PRESIDENT said the members were indebted to Prof. Liveing for bringing this matter before them. In deep mines where they had to work long distances underground a slight deviation in setting out the base-line at the shafts became of great importance when they reached distant boundaries, and it was therefore very necessary that every care should be taken in putting the base-line in its proper position.

Mr. JOHN NEVIN moved that a vote of thanks be given to Mr. Liveing for his paper.

Mr. JOHN GERRARD said that anything which could promote accuracy of plans of mines deserved the consideration of mining engineers. He seconded the vote of thanks to Mr. Liveing for his paper.

The motion was carried.

ELECTION OF OFFICERS FOR 1899-1900.

The scrutineers reported the results of the election as follows :—

PRESIDENT:

Mr. W. H. CHAMBERS.

VICE-PRESIDENTS:

Mr. H. ST. JOHN DURNFORD. | Mr. F. N. WARDELL.

Mr. J. R. ROBINSON WILSON.

COUNCIL:

Mr. J. E. CHAMBERS.	Mr. J. MELLORS.
Mr. WALTER HARGREAVES.	Mr. H. B. NASH.
Mr. J. LONGBOTHAM.	Mr. L. T. O'SHEA.
Mr. J. L. MARSHALL.	Mr. E. W. THIRKELL.

SECRETARY AND TREASURER:
Mr. T. W. H. MITCHELL.

REPRESENTATIVES ON THE COUNCIL OF THE INSTITUTION OF MINING ENGINEERS, 1899-1900.

The scrutineers reported the result of the election as follows:—

Mr. W. H. CHAMBERS.	Mr. J. NEVIN.
Mr. H. ST. JOHN DURNFORD.	Mr. C. E. RHODES.
Mr. W. E. GARFORTH.	Mr. F. N. WARDELL.

The PRESIDENT moved a vote of thanks to the scrutineers for their services.

Mr. E. W. THIRKELL seconded the resolution, which was cordially adopted.

DISCUSSION OF MR. W. W. CLAYTON'S PAPER ON "THE USE AND ABUSE OF COLLIERY LOCOMOTIVES."*

Mr. T. W. H. MITCHELL asked whether they could use steel tubes with ordinary colliery water.

Mr. W. W. CLAYTON replied that brass tubes were composed of copper and zinc. If a fuel were used containing a large amount of sulphur, the tubes thinned immediately in front of the ferrule at the fire-box end of the boiler, and collapsed in a few months. With steel tubes there was no trouble unless the water contained free acid. Iron and steel tubes, fitted with copper ends, were used with the idea that they could not make a tight joint with a steel tube in a copper plate; but that was a mistaken opinion, as a tight joint could be made in a round hole if they obtained metallic contact. If they inserted a tube covered with scale, the water acted on the scale and the tube began to leak. They experienced trouble in repairing locomotives, as they could not expand a steel tube into an irregularly-shaped hole, as efficiently as they could insert a brass or copper tube. Steel tubes had been in use for 10 years, and were still serviceable. The same remarks applied to iron tubes, but they were not so ductile as steel.

* *Trans. Inst. M.E.*, 1899, vol. xvii., page 212.

Mr. H. St. John Durnford said that he had used steel tubes, and they had lasted 4 years, and might last 4 years more. The fuel used contained much sulphur.

Mr. Mitchell enquired whether the steel tubes had copper ends.

Mr. Durnford replied that the tubes were of steel throughout.

The President (Mr. W. H. Chambers) remarked that his experience with regard to steel tubes had not been favourable. He had tried them both bare and with copper sleeves, but they did not last as long as copper tubes. He could corroborate Mr. Clayton's statement as to the speedy deterioration of brass tubes, and he had adopted red metal tubes—he did not know its constituents—but it lasted much longer than brass.

Mr. M. H. Habershon asked Mr. Clayton to explain more fully his suggestion about reducing the number of tubes in colliery-locomotive boilers, as the practice referred to and condemned was in very general use. He thought that the comparatively low value of the tube heating surface was due more to the difficulty of getting the heat out of the gases into the tubes than in the transmission of heat from the tubes to the water. The greater conductivity of copper and its durability with bad water were not the only reasons for the general preference of this metal to steel. Old copper tubes always had a value, whereas worn out steel tubes might be considered scrap. With steel tubes, the force used to plug a leaky tube had a tendency to develop incipient weakness in adjacent tubes, but this did not occur with copper tubes owing to their greater flexibility. He had been informed of a case, in which steel tubes had all gradually failed from this cause, and had been replaced by copper within 2 years. He did not know whether any experience had been obtained as to the durability of Serve tubes in locomotive boilers in this country, but they were used elsewhere, and an economy of fuel equal to 10 per cent. had been stated, and also that there was less expansion and contraction. Where the water and fuel used were suitable for steel, perhaps Serve tubes would be found to give good results, although involving extra trouble in cleaning. He could confirm Mr. Clayton's statement that in many cases insufficient provision for expansion and contraction at the fire-box end was the cause of failure in colliery-locomotive boilers.

REPORT OF COMMITTEE UPON RECOVERY-STATIONS.

With respect to the establishment of recovery-stations, your committee are of opinion that stations should be fixed at the following centres:—(1) *Sheffield:* Nunnery, Tinsley, and Birley. (2) *Tankersley and Worsboro':* Newton Chambers, Wharncliffe Silkstone, Barrow, Strafford, and Hoyland. (3) *Wombwell:* Houghton, Darfield, Mitchell Main, Wombwell, Cortonwood, and Elsecar. (4) *Mexbro':* Manvers Main, Hickleton, Wath, Denaby, and Cadeby. (5) *Rotherham:* Thrybergh, Aldwarke, Rother Vale, Rotherham Main, and Waleswood. (6) *Cudworth:* Monckton, Carlton, Monk Bretton, Grimethorpe, and Oaks. (7) West Yorkshire.

The following plant should be supplied to each of these centres, and periodical instructions should be given in the use of the apparatus:—

ESTIMATE OF COST PER STATION.

	£
12 pneumataphores ...	96
12 electric lamps ...	36
Building ...	100
First cost ...	£232

ANNUAL COST.

	£
1 man half his time, £1 per week ...	52
Upkeep, 20 per cent. on £232 ...	46
	£98

Also the cost of instruction to workmen.

To carry out this work fully, it would be necessary that the plant should be kept at a colliery connected with the telephone and where electric light is used, so that the required lamps could be kept constantly charged, and one man should be made responsible for the upkeep and proper order of the apparatus. It is suggested that the colliery where the plant is located should have two men, in addition to the caretaker, thoroughly instructed in the working of the recovery-apparatus, and that each colliery in the group should arrange to send a number of men, on a date to be mutually agreed upon, to practice in each week, and that these numbers and practices should be constantly kept up.

The estimated cost of a full plant is £250 per station, and upkeep say £100 per annum. The defraying of this expense the committee think could be easily arranged among the grouped collieries, in addition to the expense of sending men over to the station for weekly instruction.

The committee consider that arrangements could be made with the proprietors of the apparatus for the necessary preliminary instructions, and they would recommend that the men selected from the grouped collieries should be officials or workmen of a practical character, and that they should be fully conversant with the rules and regulations of the Coal Mines Regulation Acts and with all the suggestions laid out in Mr. Garforth's paper,* and should be passed by medical men as being constitutionally strong enough for the work.

The committee also suggest that doctors who are acting for the Coal Owners' Indemnity Company should be asked to assist, and if possible attend a few of the instruction classes with a view to teaching those present the rudiments of ambulance work.

Mr. H. S. Childe asked whether any member of the committee had used the pneumataphore. He thought that the proposed scheme was drafted on too costly and on too large a scale.

Mr. H. St. John Durnford replied that the committee had not had occasion to do so, fortunately. He believed that a pneumataphore had been shown at South Kirkby colliery with very satisfactory results, and that was the only occasion where one had been used in Yorkshire.

Mr. J. Gerrard said that the establishment of a station in South Yorkshire and another in West Yorkshire was very desirable, and in that way, ultimately, they might attain the number of stations suggested by the committee.

Mr. E. W. Thirkell thought that the scheme of the committee was ambitious, and that it would not be desirable to buy a pneumataphore unless the members were assured that they should be able to get men to use it.

Mr. C. C. Ellison said that the committee had not had the pneumataphore in the pit, but he had seen it used in Germany under most trying circumstances, and the work done by the men registered. The stations should be maintained at collieries, where the pneumataphores could be looked over by a man, who would keep them in order. If the station was placed in a village, the cost would be much greater. If the workmen had to travel to Leeds to the station, they would not

* *Trans. Inst. M.E.*, 1897, vol. xiv., page 495.

get the same opportunities of practice as if they had a station at a convenient colliery. He did not think that there was a better instrument than the pneumataphore in use on the Continent or anywhere else.

Mr. W. E. Garforth thought that there would be no difficulty in introducing the use of the pneumataphore and in ascertaining the best means of employing oxygen and other appliances which would be found useful in recovering underground workings after an explosion. Judging by the success which had attended the St. John's ambulance movement, there should be no difficulty in obtaining, for training purposes, the use of suitable buildings from local authorities in the small towns or villages connected with the mining centres. In the meantime, an experimental gallery, with suitable outlets and windows to reduce or avoid the chance of an accident, might be constructed, with the floor made very uneven to represent the *debris* from the falls of roof usually met with in roads traversed by an explosive blast. When such a gallery had been erected on the surface, and filled with noxious fumes, then the would-be explorers should be supplied with the pneumataphores and penetrate the same; and he believed that, although they might only be able the first time to go a short distance, it would not be very long before they became so accustomed to the use of the apparatus that they would be able to traverse several lengths of the gallery. In this way the men would train themselves to know to what extent they could undertake the exploration of a road down the pit. If this experiment could be practically carried out, he thought that the knowledge gained thereby would be sufficient to warrant the committee in adopting further tests, not only in the use of the pneumataphore, but in other appliances which might be found useful in recovering a mine after an explosion.

The President (Mr. W. H. Chambers) thought that the committee should be asked to arrange for a practical demonstration of the use of the pneumataphore.

Mr. W. E. Garforth said that, in the absence of any other proposal, he was prepared to offer facilities at the West Riding collieries for trials of the pneumataphore something on the lines suggested.

The President said that no doubt the committee would accept Mr. Garforth's offer.

DISCUSSION OF MR. L. T. O'SHEA'S PAPER ON "THE SAFETY OF MODERN MINING EXPLOSIVES, WITH SPECIAL REFERENCE TO METHODS OF TESTING."*

The PRESIDENT (Mr. W. H. Chambers) remarked that at the Woolwich testing-station there was no facility for photographing the flames, nor any other information as to the danger of using explosives. Under these circumstances mining engineers would agree that it was desirable to erect a testing-station where they could have the explosives tested on a proper scale, under conditions as nearly as possible approaching those under which they were used in mines. It was generally recognized that mining engineers did not accept with confidence the results of the Woolwich experiments, and that they would prefer to carry on experiments in their own way.

Mr. H. ST. JOHN DURNFORD remarked that Mr. O'Shea stated that explosives on the "permitted list" were only comparatively safe, and that it was for mining engineers to consider which in their opinion was safest. He understood that an absolutely safe explosive had not been found. Recently an explosive had been taken off the "permitted list," and he had not the slightest doubt that there were others which, if properly tested, should also be removed. Detonators had been for a long time the most dangerous part of the explosive. Ordinary explosives were safe to carry in the hand, but detonators were not safe, and he welcomed the rule to keep detonators in a locked case. He had kept detonators in a separate case from explosives, and now that they were to be kept in locked cases they could not be used by unauthorized persons.

Mr. I. HODGES (Whitwood) said that the miners sometimes kept detonators stored in the roadways of the colliery. It would be desirable if the miners could store the detonators after purchase from the company, before taking them away for use in the mine.

Mr L. T. O'SHEA said it had been shown that if they took an explosive, the safety of that explosive with regard to the ignition of fire-damp in mines depended upon the weight of the explosive which was present. Experiments made in Germany had shown that, by increasing the charge in the shot-hole, they could eventually reach a maximum charge with which fire-damp would be ignited by any safety-explosive,

* *Trans. Inst. M.E.*, 1899, vol. xvii., page 189.

There was a particular maximum of weight for each explosive, beyond which they could not go without ignition taking place. The weights used in Germany varied between 7 and 8 ounces, but in Great Britain from 2 to 2½ ounces of explosive were tested, and the only explosive which would ignite fire-damp with a weight of 2¼ ounces were dynamite and blasting gelatine, the use of which had long ago been discarded in coal-mines. By the last Home Office Order, argus-powder had been removed from the "permitted list," which showed that in one case at least the doubts of mining engineers as to the efficiency of the Home Office test were justified. In his opinion no test was satisfactory which did not afford the means of comparing the safety of different explosives when weights equal to those used in actual blasting were fired.

The Annual Dinner was held in the evening at the Queen's Hotel, Leeds.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE CHRISTIAN INSTITUTE, GLASGOW, OCTOBER 11TH, 1899.

MR. JAS. F. FORGIE, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen were elected :—

MEMBERS—

Mr. DANIEL BURNS, Flowerbank, Carluke.
Mr. DAVID M. RITCHIE, Emilybank Cottages, Gorebridge.

ASSOCIATES—

Mr. ROBERT PEGGIE, Wallyford Colliery, Musselburgh.
Mr. DANIEL RUSSELL, Cowie, Bannockburn.
Mr. ROBERT STRACHAN, 7, Manse Road, Shotts.

DISCUSSION OF MR. GEORGE L. KERR'S PAPER ON "TIMBERING AND SUPPORTING UNDERGROUND WORKINGS."*

The SECRETARY, in connexion with this subject, referred to a proposal which had been made at the February meeting of The Institution of Mining Engineers, held at Stoke, for the appointment of a committee to examine and report upon the various systems of propping. The Council of the Institution afterwards considered the matter, and agreed that the views of the various Institutes should be asked regarding the proposal.

After considerable discussion, in which the opinions expressed were on the whole favourable to the appointment of a committee, it was remitted to the Council to consider the matter and communicate with The Institution of Mining Engineers on the subject.

The further discussion of Mr. Kerr's paper was adjourned.

* *Trans. Inst. M.E.*, vol. xvi., pages 230 and 430; vol. xvii., page 168; and vol. xviii., page 57.

DISCUSSION OF MR. ROBERT WEIR'S PAPER ON "THE DOUGLAS COAL-FIELD, LANARKSHIRE."*

Mr. R. WEIR, replying to Mr. R. W. Dron's† criticisms, said that he did not dispute the approximate correctness of Mr. Dron's figures computed from the area and thickness of the coal-seams in the Carboniferous Limestone Series in the Rigside district, but it should be borne in mind that for over 200 years these coals had been wrought along their outcrop, and also that shafts and ingoing-eyes had been in operation for over a century. The thinning out of the coal-seams to the west, and a large extent of waste workings, now filled with water and probably augmented from the Douglas stream, which will have to be supported, combine in reducing the quantity of profitable accessible coal to his estimate of 15,000,000 tons.

A cordial vote of thanks was awarded to Mr. Weir for his paper, and the discussion was closed.

DISCUSSION OF MR. THOS. H. BARR'S PAPER ON "TWO TYPES OF ELECTRICAL COAL-CUTTERS."‡

Mr. FRED. W. HURD wrote that Mr. Barr had ably described the two machines, and to his description of the bar-machine he had nothing to add, but he wished to draw the attention of the members to the main points of difference between the two types: (1) The disc-cutter revolves from 20 to 30 revolutions per minute, and the cutter-bar from 400 to 500. The actual speed in feet per minute of the cutting tool is practically the same in both cases, but the high speed of the cutter-bar is a great advantage when electricity is the motive power, as only one reduction of gearing is required, namely, 2 of the motor to 1 of the bar. With a disc-cutter, three reductions are necessary, and this complicates the gearing and entails a considerably greater number of parts subject to wear and tear. (2) The bar-cutter requires considerably less power to drive it than the disc-cutter. He had had the opportunity of testing both types in the same seam. With the same depth of undercut, 4 feet 6 inches, and the same cutting rate of 18 inches per minute, the disc-machine took from 45 to 65 ampères at 400 volts, while the bar-machine only took 26 to 30 ampères at 400 volts. From these results it is clear that the engine, dynamo and cables for the bar-machine can be 30 per cent. smaller, and consequently cheaper than for the disc-machine. (3)

* *Trans. Inst. M.E.*, vol. xvi., page 436; vol. xvii., page 170; and vol. xviii., page 53. † *Ibid.*, vol. xviii., page 53. ‡ *Ibid.*, vol. xvi., page 447.

The bar-cutter is safer than the disc-cutter. It is placed entirely under the coal, and there is no danger of the machineman coming into contact with the picks, under ordinary working conditions. The coal is more securely spragged, as sprags can be placed below the coal undercut within 18 inches from the solid coal, as against 18 inches *plus* the diameter of the disc, in the case of a disc machine. Wherever machines can be adopted a bar-machine will do the work.

The discussion was closed, a hearty vote of thanks being given to the author.

DISCUSSION OF MR. W. D. L. HARDIE'S PAPER ON "MACHINE-MINING AND PICK-MINING COMPARED."*

Mr. Thomas Arnott (Newton) said that he knew of an instance where a machine had proved successful, after the pick had been tried and had failed. This was principally owing to water which percolated through the roof from an old waste (9 feet above) which had been wrought on the stoop-and-room system, and the stoops left were so small as to prevent their extraction. The working-faces, while under the old rooms, were usually dripping with water, and thus men could not be got to work them unless at a prohibitive price.

Mr. A. Blyth (Hamilton) said that experience at the Bent colliery had been all in favour of pick-mining, which could be done much more cheaply than machine-mining. Machines, no doubt, were useful when the strata were settled, but when, as in the case of the Bent colliery, they were not, then machines were found to be of very little use.

The President (Mr. J. T. Forgie) said that he had some little experience of machine work, but it had not proved very satisfactory. Notwithstanding that experience, he did not think one could say that the machine-working of coal was a mistake. Many things, in his opinion, required to be taken into consideration before one could say which was the better of the two—machine-mining or pick-mining. There was no machine at present which could beat handwork in a thick coal-seam. Where there was a thin coal-seam, however, and hard holing, a reliable machine would be of considerable advantage and utility. In working with machines numerous difficulties were to be encountered, and so far as he knew a machine had not yet been invented which could satisfactorily, and under all conditions, cut coal-seams under 2½ or 3 feet thick, and certainly seams of 3 feet thick and above could be

* *Trans. Inst. M.E.*, 1899, vol. xvii., page 171.

wrought more cheaply by hand than by machine. He looked forward to the time, when electrical engineers would construct a machine capable of working such seams, and this would further reduce the number of breakdowns and repairs. When they looked forward to having a good night's work with the machine, there was almost certainly a breakdown. That was his experience, and he knew that it was the general experience where machines were in operation in several other collieries. In conclusion, the electrical engineers of the future would probably provide mining engineers with the necessary machinery of a compact and thoroughly applicable character which would be utilized for coal-seams, 2½ feet thick and under.

Mr. T. Arnott said that it did not require a first-class mechanic to attend to the machine, but that, if a good handy man could be got who was anxious to keep the work going, there was little chance of stoppages through breakdowns.

The President (Mr. J. T. Forgie) asked Mr. Arnott, to what kind of machine he referred.

Mr. R. Arnott replied that he meant the Gillott & Copley machine, which worked efficiently in a seam only 2 feet 4 inches thick.

The further discussion was adjourned.

REPORT OF THE DELEGATE TO THE CONFERENCE OF DELEGATES OF CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, DOVER, SEPTEMBER, 1899.

By JAMES BARROWMAN.

A few years ago this Institute was included in the list of Corresponding Societies of the British Association for the Advancement of Science. The effect of this is that a delegate appointed by the Institute becomes a member of the British Association for the Advancement of Science, and is entitled to a place on the General Committee which has the voting of grants of money to meet the expense of experiments and investigations in various departments of scientific inquiry. He is also a member of the Conference of Delegates of Corresponding Societies. This Committee, at each annual meeting of the Association, takes into consideration one or two subjects which may engage the attention of the various societies which it represents.

It is obvious that a large number of societies, some of them with hundreds of members, situated in all parts of the United Kingdom, and associated together in a common object, can do much more in any subject of investigation than a single organization is able to effect.

At the meeting at Bristol last year, a resolution was passed by the Conference as to the desirability of carrying on systematic observations of the extent of erosion going on along our shores, and the consent of the Admiralty was obtained to the co-operation of the Coastguard in this work.

The meetings of the Committee held this year at Dover were two in number. At the first meeting, a paper was read by the Rev. R. R. Stebbing, advocating the observation and collection of specimens of the living subterranean fauna of Great Britain and Ireland. The writer was evidently an enthusiast and an authority on the subject, and his paper was both interesting and amusing. His recommendation was that members (as they had opportunity) should examine underground caves and wells for specimens of land and water animals peculiar to these situations--not occasional visitors, but such animals as had become habituated to underground existence. While this may be an interesting and even fascinating pursuit to a few zoologists or entomologists, it is plain that it cannot be taken advantage of to any great extent by the Corresponding Societies. There was little discussion at the meeting, the reason probably being that the subject was not of general interest. There may be difficulty in selecting subjects which will appeal to the majority of the societies, but it seems to the writer that this should be aimed at perhaps to a greater extent than is done at present.

That these Conferences are not so satisfactory as is desirable is shown in the fact that the Secretary of the Corresponding Societies Committee has issued a circular inviting recommendations from the delegates as to the best means of improving the proceedings of these meetings.

The second meeting of the Committee was held on the closing day of the meetings, when a paper was read by Mr. Hugh Blakiston on "The National Trust for Places of Historic Interest or Natural Beauty"; but unfortunately your delegate could not attend, as he had to be present at the Sheffield meeting of The Institution of Mining Engineers.

An opportunity was afforded of examining several albums of photographs of geological interest which have been collected by the Committee. These photographs were of sections of strata and other geological features from numerous districts in the United Kingdom. It seems to your delegate that members of this Institute who use the camera could do good work on holidays and at other times in photographing sections of strata wherever exposed in railway or other cuttings and in river-banks and sea-cliffs and shores, and opportunities arise from time to time to record some geological feature opened to view for a temporary purpose, which, if not taken advantage of at the time, may be never had again.

Perhaps the most interesting subject to this Institute which engaged the attention of the Geological Section of the Association was that of the explorations in Kent for coal. Prof. W. Boyd Dawkins reported the result of some boring explorations in operation; but as they are incomplete it is impossible to give very definite results. Of 7 bore-holes put down to depths varying from 700 to over 2,000 feet only 2 found coal, one at Shakespeare Cliff, Dover, where it is reported that there are 8 coal-seams amounting to 16 feet, the thickest being 4 feet; and the other at Ropersole, some 7 miles distant, which is said to have passed into the Coal-measures and cut through a 9 inches seam of coal at a depth of 1,650 feet and a 6 inches seam at a depth of 1,710 feet.

The PRESIDENT moved a vote of thanks to Mr. Barrowman for his report, and the motion was cordially adopted.

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

ANNUAL GENERAL MEETING,

HELD AT MASON UNIVERSITY COLLEGE, BIRMINGHAM, OCTOBER 9TH, 1899.

MR. JAMES LINDOP, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting and of Council Meetings were read and confirmed.

The following gentlemen were elected :—

ASSOCIATE MEMBER—

Mr. BERNARD HADRA, Kaltennordhein, Germany.

STUDENTS—

Mr. GEORGE LAW MACKENZIE, Craigwell, Ayr, N.B.
Mr. PERCIVAL JOHN PERRY, Mayfield House, Wolverhampton.

The Annual Report of the Council for the past year was read as follows :—

ANNUAL REPORT OF THE COUNCIL, 1898-99.

The Council have pleasure in presenting their thirty-second Annual Report. The year, as far as the work of the Institute is concerned, has been a fairly successful one. The increase of membership recorded in the previous year's report has been maintained, and there are now 173 members as compared with 172 on the list for the previous year. Unfortunately several members have been struck off for non-payment of subscriptions or the accession of new members would have much more increased the total. The following papers have been read :—

"Observations on the Relation of Underground Temperatures and Spontaneous Fires in the Coal to Oxidation and to the Causes which favour it." By Dr. Haldane and Mr. F. G. Meachem.

"The Midland Electric Power Corporation and its Bearing on Mining in the District." By Mr. G. L. Addenbrook.

"The Martin Turnbull System of Water-sprays." By Mr. F. G. Meachem.

The paper read by Messrs. Haldane and Meachem has elicited valuable and interesting discussion.

The Council of The Institution of Mining Engineers has decided that the Institution shall only hold two general meetings during the year, one general meeting in London and the annual meeting in the Provinces.

Upon referring to the accounts, the members will find that the bank balance shows a slight decrease compared with last year. This is caused by the increased subscriptions paid to The Institution of Mining Engineers, and also by the large amount owing to the funds of this Institute by members whose subscriptions are in arrear. Several of the other Institutes have gone through the same experience, and have raised their subscriptions.

The balance-sheet shows a slight decrease in the amount standing to credit of the Institute, this being due, not to any material depreciation of the assets of the Institute, but owing to the deduction from the assets of "subscriptions due," which appeared in the balance-sheet for last year, and comprised money owing by several members who have been struck off by the Council during the year, in accordance with the rules, and to the slightly smaller bank balance.

The Institute continues a Corresponding Society of the British Association for the Advancement of Science, and receives its proceedings. Transactions of many of the leading kindred societies of the world are also presented to the Institute.

Timbering in mines has been brought prominently before mining engineers by the Home Secretary, and The Institution of Mining Engineers has referred to the local Institutes the desirability of appointing a committee, so that this question should soon receive attention.

The report of the past year of The Institution of Mining Engineers, which has been recently presented, shows that it has 2,416 members on its roll, and that 62 interesting papers have been read. The report also draws attention to the general decrease of membership of the Federated Institutes, owing to the non-payment of subscriptions.

The Council desire to call attention to the great honour conferred on one of your members, Mr. H. C. Peake, who has been elected President of The Institution of Mining Engineers for the coming year.

Your thanks are again due and are hereby tendered to the authorities of Mason University College for providing rooms for meetings.

The Council have again to strongly urge the members to use their best endeavours for the advancement of the interests of the Institute, and regret that their previous appeals have not met with greater response, as they think that the members may do much more for the

Dr. THE TREASURER IN ACCOUNT WITH THE SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS, FOR THE YEAR ENDING JULY 31ST, 1899. **Cr.**

	£	s.	d.		£	s.	d.
To Balance in Bank	373	13	5	By Calls paid to The Institution of Mining Engineers ...	125	4	2
„ Subscriptions received	190	9	0	„ Secretary's and Reporter's Salaries	50	0	0
„ Sale of *Transactions*	2	1	6	„ Rent, Rates, Gas, etc., for Institute Room	20	0	0
„ Bank Interest	5	1	5	„ Expenses of attending Meeting of The Institution of Mining Engineers and of Audit	4	5	0
				„ Stamps, Parcels, Telegrams, etc.	6	8	9
				„ Printing Circulars, Lists of Members, etc.	6	10	10
				„ Balance in Bank	358	16	7
	£571	5	4		£571	5	4

BALANCE-SHEET, 1898-99.

Liabilities.	£	s.	d.	**Assets.**	£	s.	d.
To The Institution of Mining Engineers	17	7	4	By Balance in Bank	358	16	7
„ Balance	425	6	3	„ Subscriptions due	83	17	0
	£442	13	7		£442	13	7

Examined and found correct,

DANIEL ROGERS, W. H. WHITEHOUSE, } *Auditors.*

October 9th, 1899.

This is exclusive of considerably more than £100 worth of property, for which no credit is taken.

Institute by attending the meetings and reading papers, and introducing new members than they do at present.

With the view of obtaining a larger attendance at the meetings, and in response to the opinion expressed by several of the members, the Council have resolved that the meetings shall be held on Monday instead of Thursday, which, it is hoped, will prove a more convenient day, and result in larger attendances of members at the meetings.

Mr. J. Lindop moved the adoption of the report.

Mr. W. J. Haywood seconded the motion, which was adopted.

ELECTION OF OFFICERS FOR THE YEAR 1899-1900.

The Scrutineers reported that the following officers had been elected for the ensuing year :—

President.—Mr. James Lindop.

Vice-President.—Mr. Fred. G. Meachem.

New Members of Council:

Mr. W. Charlton.	Mr. George Turner.
Mr. T. J. Davies.	Mr. W. H. Whitehouse.

Mr. W. B. Scott (H.M. inspector of mines) in moving a vote of thanks to the officers for their services during the past year, said that they were particularly indebted to Mr. Lindop for consenting to continue as President. He was one of the oldest members of the Institute, and his knowledge of mining in Staffordshire might be regarded as unique. The other officers had carried on the work of the Institute on correct principles. They did their utmost to stir up interest and to induce members to write papers and to take part in discussions.

Mr. W. H. Whitehouse seconded the motion, which was approved.

The President (Mr. J. Lindop), in replying, said that nothing would have induced him to accept the presidency for a second term otherwise than to relieve the Council from the difficulty created by the retirement of the Vice-President who should have been elected President. He considered that it was of the highest importance that the President and Council should consist of gentlemen of high standing and experience, who were actively engaged in mining. He feared that young engineers did not duly appreciate the advantages of being members of a mining society of high character (and one of the oldest mining

institutes), where they could meet and discuss the different questions, scientific and practical, relating to mining. It was essential that engineers of the present day, who were entrusted with the opening, developing, and working of mines should be thoroughly efficient and give evidence of their ability to undertake such an important position. The responsibilities of mining engineers were not so great 50 years ago as at the present time. Then the coal-seams were found at shallow depths, and it was not an uncommon practice to commence sinking a shaft in the morning and strike the coal a few days later. Now, in some cases, the coal-seams are found at a depth of more than 3,000 feet, and it will take from 3 to 4 years to sink, open and develop a mine. It was thought, from 30 to 50 years ago, that the coal-mines in South Staffordshire were nearly exhausted and that the ironworks would have to be closed in consequence. He was sorry that some ironworks had been closed (not yet from that cause) owing to high railway dues. There is no fear, however, of a coal-famine in Great Britain for a long time to come, notwithstanding the prodigal waste and consumption both for manufacturing and domestic purposes. A few years ago large collieries were opened at Sandwell Park, Aldridge, and Walsall Wood and in the Pensnett district, but still more recently the important sinking at Littleton colliery (formerly Huntington) has reached the Deep and Shallow coal-seams at a depth exceeding 1,600 feet. He was optimistic enough to believe that Coal-measures would be found, when required, between South Staffordshire and Shropshire, and the Warwickshire coal-field. He was informed that the coal-seams at Haunchwood colliery in Warwickshire could be correlated with the Thick coal-seam at Hamstead colliery. The coal-seams in the unexplored districts may lie at great depths, probably 3,000 feet or more, but at whatever depth they may be found, mining engineers, with improved and powerful machinery, scientific appliances, and shafts of large diameter will bring them to the surface. As mining is so important a factor to every branch of trade, and as our commercial interests are so dependent upon it, may we not hope that the education of mining engineers in the new Midland University will not be neglected? He hoped that every member would endeavour to attend the meetings, contribute a paper, or take part in the discussions.

A paper by Mr. Francis Olds on "The Witwatersrand Gold-fields" was read as follows :—

THE WITWATERSRAND GOLD-FIELDS.

By FRANCIS OLDS.

Introduction.

The Witwatersrand gold-fields are the most important and the most productive of all the gold-fields of the world. The Witwatersrand (or shortly the Rand) consists of a series of banket beds 40 miles in length, unlimited apparently in depth, and payable over the greater part of the entire area. The city of Johannesburg is situated in the centre of the gold-fields.

The yield of gold from the Rand, from the commencement of mining operations to August, 1899, has been £76,720,000. The yield in 1887 was £80,397, and in 1898 £15,141,376. The output of gold in 1898 was over 4,500,000 ozs.

For a number of years to come an average yield of £20,000,000 may be confidently expected, and there is ore in sight to ensure a large output for forty years more. There are at present 160 mines being worked on the Rand, while a number of others, chiefly to work deep-level areas, are in course of formation.

The mines, within whose surface-areas the reefs that are being worked, come to the surface, are known as "outcrop mines"; and in relation to these, those which are situated vertically over the immediate extension of the reefs dipping from the outcrop mines, are known as the first row of "deep-level mines." The average distance of the northern boundary of the deep-level mines from the outcrop, along the Witwatersrand, is about 1,300 feet. Farther south lies the second row of deep-level mines; these are situated over the reef as it extends downward from the first row of deep-level mines; the average distance of the northern boundary of these mines from the outcrop is about 4,000 feet.

Geology.

Banket is the name given by the Dutch to an auriferous conglomerate which, in its weathered appearance resembles "almond-rock." This conglomerate occurs in beds intercalated in greater part through the

quartzite formation, known as the Witwatersrand Beds. The beds resting immediately on the granite of the Primary formation form the elevated tract known as the Witwatersrand.

The strata consist of hard white quartzites alternating with bluish clay-shales, the latter being highly impregnated with oxides of iron. The series, designated the Quartzite-Shale group, is a very characteristic and important geological feature, as it immediately underlies the auriferous conglomerates or banket beds of the Main Reef Series, and is invariably associated with them. To the south of the Quartzite-Shale group, and overlying it, is a thick series of reddish sandstones and quartzites, which at intervals enclose conglomerate-deposits of greater or less thickness. These beds are conformable with the underlying group, having like the latter an east-and-west strike, with a southerly dip. About 3 miles south of the Rand hills the beds are capped by a hard fine-grained greenstone or melaphyre, which rises into the Klipriversberg Range. South of this again are more sandstones, and in these occur the highest conglomerate-beds of the series, namely, the Black Reef. The Witwatersrand Beds have been correlated with the Table Mountain Series and with the Lower Devonian or Old Red Sandstone in the European sequence.

Banket in the Quartzite-Shale Group.—This group lies on the granite, and those forces which altered that rock into gneiss and schist have also altered this overlying group, so that in places the origin of some of its component beds is problematic. The beds are generally distorted and broken. The most important development of this banket occurs on the New Rietfontein Estate and Rietfontein A, two properties situated 10 miles east-north-east from Johannesburg and about 2½ miles north of the line of the Main Reef Series. In these mines there are three principal reefs, known respectively as the North Reef, Middle Reef and the Leader, and collectively as the Du Preez Series. The North Reef varies from 8 inches to 36 inches in thickness; it lies upon slate, about 30 feet north of the Middle Reef; its gold-content is irregular. The Middle Reef and the Leader generally occur in such close proximity that they are mined together; the former averages about 10 inches in thickness and the latter 6 inches. In addition to these reefs, there is the Stable Reef; the outcrop of this reef is about 200 feet south of that of the Middle Reef.

Banket in the Witwatersrand Beds.—The complete series of banket-beds in this formation is generally considered to be as follows, placed in

ascending order:—(1) Main Reef Series; (2) Livingstone Reef Series; (3) Bird Reef Series; (4) Kimberley Reef Series; and (5) Elsburg Reef Series.

Main Reef Series.—This is the first banket series met with overlying the Quartzite-Shale group, and it is separated from the shales of that group by an average thickness of 150 feet of quartzite. This series consists principally of three reefs, which, commencing from the lowest, are known respectively as:—(1) The Main Reef; (2) the Main Reef Leader; and (3) the South Reef; and, in addition, there are many less important banket-beds.

The great bulk of the gold-output of the Transvaal is obtained from the Main Reef Series. The Main Reef consists of several beds of banket, with an average thickness of about 7 feet, separated from one another by layers of quartzite, with an average thickness of about 3 feet, making in all a total thickness of about 10 feet. The pebbles are chiefly of white quartz, with a proportion of black quartz, and all are well rounded. The cement or matrix which fills up the interstices between the pebbles is chiefly siliceous and chloritic material, containing, in addition, a small percentage of iron-pyrites. The average gold-content of this reef is about 5 dwts. to the ton.

This reef is separated from the overlying Main Reef Leader by about 3 feet of quartzite. In some places, as in the Ferreira mine, these two reefs are so close together, and the Main Reef so much better in grade, that the identity of the two is difficult to determine. The pebbles of the Main Reef Leader have a larger average size than those in the Main Reef. They are usually "frozen" hard into the quartzite of the hanging-wall, but are separated from that of the foot-wall by the strongly developed bedding-plane, which is characteristic of this reef. The Main Reef Leader, in the Ferreira mine, has an average thickness of 15 inches, and an assay value of about 30 dwts. per ton. The general nature of the banket of this reef is identical with that of the Main Reef.

The South Reef overlies the other two, and is separated from the Main Reef Leader by a bed of quartzite about 70 feet thick. The pebbles of this reef are smaller than those of the other reefs, but in all other respects the banket is very similar to that of the Main Reef Leader. Where there are three leaders, the upper one is usually of low grade, the middle one rich, and the lower one is often rich but irregular; and where there are only two leaders, the upper one is of low grade and the lower one rich.

In addition to these principal reefs, there are other unimportant banket-beds.

Dykes and Faults.—Like other stratified formations that have been tilted from an horizontal position, the Rand beds have been fractured, dislocated, and pierced by intrusive masses of igneous rock. The dislocations along the Rand, in relation to the direction of stratification, may be divided into three groups:—(1) Longitudinal dislocations, which run more with the strike of the formation than across it; (2) transverse dislocations, which run more across the strike of the formation than with it; and (3) bedded dislocations, which separate the planes of the reefs. The transverse dislocations are most noticeable in the Krugersdorp district. In the Central Rand, there is no regular series of transverse dislocations; there are, however, many dykes which cut almost directly across the formation, but these rarely disturb it to any extent.

The Robinson mine is divided very equally into two parts by a large dyke which is about 230 feet thick and has no perceptible throw. It is composed of a coarsely crystalline igneous rock similar to that of the longitudinal dykes which cross it. According to a list of the transverse dykes opened up in the immediate neighbourhood of Johannesburg, twenty-five dykes are accompanied by normal throws, and one has a reverse throw. The average angle of a dip is 83 degrees, and the direction is distributed equally between east and west.

In the Central Rand there is a very pronounced series of longitudinal dislocations. The most noticeable of the bedded dislocations are those which occur in the Central Rand, between the Main Reef and the Main Reef Leader.

There are forty-six dislocations in the Central Rand, and with regard to these the following points deserve notice:—(1) There are twice as many transverse as longitudinal dislocations. (2) There are twice as many dislocations which dip to the south as dip to the north. (3) The transverse dislocations dip at a steeper angle than the longitudinal. (4) The longitudinal dislocations are almost all right-handed. (5) Of forty-six dislocations only seven are reverse ones. (6) Of these latter, six are longitudinal dislocations, the remaining one being a transverse dislocation. Of these dislocations, twenty-three, or one-half, are dykes having an average thickness of about 50 feet, while the other half are classed as faults, their thickness being inconsiderable.

There is hardly a mine on the Rand which has not one or more dykes to contend with. Examples of big dykes may be studied in the Ferreira, Robinson, George Goch, Simmer and Rose Deep mines.

Genesis of the Witwatersrand Banket.—Several theories have been advanced to explain the origin of the conglomerate-beds, but the only one deserving serious consideration is that they are littoral sedimentary beds. The consensus of opinion of geologists who have investigated the subject is that the beds of sandstone and quartzite are the metamorphosed accumulations of marginal sea-shore deposits formed during periods of subsidence of the coast-line.

There exists, however, a diversity of opinion regarding the origin of the gold in the conglomerate-beds. The impregnation theory suggested by Mr. Gardner F. Williams commends itself most favourably to mining engineers resident in the district. This theory attributes the presence of gold and pyrites in the reefs to deposition from infiltrating solutions, as in the genesis of auriferous quartz-veins. According to this view, the mineralizing solutions have passed along the planes of least resistance, *i.e.* the interstitial spaces of the banket-reefs, and the gold has been deposited since the upheaval of the conglomerate-beds.

In the Ferreira mine, there is an interesting occurrence of a dyke containing a considerable amount of visible gold. This dyke lies below the South Reef, and is separated from it by several inches of vein-quartz.

Occurrence of Gold.—The gold occurs in a metallic condition, and is only to a small extent alloyed with other metals. The distribution of the gold in the banket is much more regular and uniform than in other auriferous deposits. The average value of the ore crushed on the Rand is 13·15 dwts. of fine gold per ton.

Deep-Level Mines.—The ore-body in the deep-level mines has much the same value as in the outcrop mines, but in consequence of a flattening of the dip the average gold content per deep-level claim is less than that per outcrop-claim in the proportion of 100 to 118.

In relation to dykes, faults, water and other natural features, the deep-level and outcrop mines are similarly situated, and the mineralogical nature of the banket (neglecting the oxidized zone now practically worked out), and the details of its bedding are in each case identical.

The only additional cost in deep-level mining compared with outcrop mining is that of sinking, equipping, and of transmitting everything through vertical shafts.

Mining Practice.

Shafts, Sinking and Timbering.—The shafts of the outcrop mines are chiefly incline shafts, which are sunk to follow as nearly as possible the inclination of the reef. Owing to dislocation by faults, it is not possible to keep the shaft on the reef continuously for any depth, or to maintain a constant distance from it. The two main inclines of the Robinson mine were driven from the surface through the upper levels at a constant inclination, which, in the lower levels, was changed to a flatter angle, because the reefs had gradually got away into the hanging-wall. There are many outcrop mines which, starting with vertical shafts, afterwards adopted incline shafts; but experience shows that this method renders hoisting more costly than continuous hoisting through an incline shaft.

Two main shafts are considered necessary at most mines, in order to facilitate development and ensure adequate ventilation. In consequence of the comparatively small area of the outcrop mines the shafts are placed only about 1,000 feet apart. In the first row of deep-level mines, the shafts are situated at an average distance of about 1,700 feet from the outcrop of the reef, at which distance the average vertical depth of the reef is about 1,100 feet. The shafts are situated about 1,600 feet apart along the strike. The shafts of the second row of deep-level mines are situated on an average about 5,000 feet from the outcrop of the reef and about 1,000 feet from the northern boundary of the properties. At this distance from the outcrop the average depth of the reef, if undisturbed, should be about 3,000 feet, but owing to the influence of reversed faults, accompanied by upthrow faults on the southern side, the depth is about 500 feet less.

The shafts are placed thus far from the northern boundaries of the properties so that there shall not be too great a length of incline shaft below the vertical shaft; otherwise, with the large extent of ground to the dip, it might become necessary to put down another row of vertical shafts.

Dimensions of Vertical Shafts.—The following are the ruling sizes of vertical shafts along the Rand:—(1) The shafts sunk on ground in which the reef crops out, are rarely more than 400 feet deep, and are few in number. The length of the shaft, inside the timbering, is 12 feet, and the width 5 feet. There are two hoisting compartments, each 4 feet long, and the pump and ladder-way is 3 feet long. Where there is only one shaft, the compartments are larger. (2) On the first row of deep-

level mines, the shafts cut the reef after it has passed out of the outcrop ground at depths varying from 700 to 1,600 feet. The length of the shaft, inside the timbering is 16 to 21 feet, and the width 6 feet. There are usually three or four hoisting compartments, each 4 or 5 feet long; and the pump and ladder-way is 6 feet long. (3) The shafts, on ground underneath which the reef lies at depths of 2,000 feet and more, are 26 feet long, inside the timbering, and 6 feet wide. There are four hoisting compartments each 4½ feet long, and the pump and ladder-way is 6½ feet long.

Size of Incline Shafts.—The average size of incline shafts is about 16 feet in length and 5½ feet in width, inside the main timbering; the length is usually divided into two hoisting-compartments of 4½ feet each, and the pump and ladder-way is 6 feet long. The City and Suburban Main incline (over 2,000 feet deep) is 20 feet long and 5½ feet wide.

Sinking.—Sinking is always assisted by charges of explosives contained in drill-holes. There are three principal methods of breaking the bottom of a shaft, namely:—(1) By drilling over the whole face in one shift, blasting the centre-holes for the "cut," and then squaring up. This method is only used with machine-drills. (2) Drilling the ends after the cut has been blasted. (3) Placing the holes to suit the formation.

Timbering of Shafts.—The shaft is timbered or supported by means of timbers arranged in frames known as sets. A complete set consists of two wall-plates, which are placed, one on either side, along the length of the shaft; of two end-plates, which are placed across the shaft at either end; and of dividers, which, by their number and position, divide the length of the shaft into the requisite number of compartments. The timber sets are placed at regular distances apart, and studdles are placed vertically between them at each corner of the shaft, and at all points along the wall-plates to which the dividers are fixed. This framework is boxed in, wherever necessary, by driving planks or lagging around the outside. The wall-plates and end-plates are usually of Oregon or pitch-pine 8 inches square, or, as in the deep-level mines, of Kauri-wood, 8 inches by 6 inches in section. The guides, which are embraced by the runners of the skip, are made of hard well-seasoned wood, which has been planed and smoothed. The lagging consists usually of 1½ or 2 inches deals. The lagging is seldom continued below

a depth of 300 feet, the rock at that depth being undecomposed and very firm. Sets are, however, often continued down to much greater depths, and dividing timbers can never be omitted, since they are essential to the carrying on of work in the shaft.

Timbering of Incline Shafts.—All incline shafts are timbered near the surface and down to solid rock, with sets comprising all the separate timbers which are used in vertical timbering. Guides are not used in incline shafts, their place being taken by rails secured to the sole-piece. Where a vertical shaft turns off on an incline, special timbering is generally used.

Circular Shafts.—There are only two circular shafts, one at the New Primrose mine, 11 feet in diameter, inside the walling, and 400 feet deep; and the other at the Langlaagte Royal mine, 15 feet in diameter, and laid out to go a depth of 900 feet.

Rate of Sinking and Cost of Shafts.—The cost of shafts includes that of sinking and timbering, and that incurred in cutting the necessary sumps and stations for the pumping system. In April, 1897, the cost of sinking 90 feet of the Roodeport Central Deep shaft was £15 per foot, including all costs. The excavation for the shaft was 23½ feet long and 8 feet wide, the measurements inside the timbering being 22½ feet and 6 feet. It is generally found that the complete cost of timbering a five-compartment vertical shaft varies from £3 5s. to £3 10s. per foot of shaft. The average cost per foot, throughout the Rand, all costs included, is about £25. The rates of sinking have been very high throughout the Rand, as there has been little water to contend with. Over 150 feet per month has been sunk in many of the shafts. The cost of shaft-sinking by hand-labour in ordinary quartzite is considerably cheaper than by machine-drilling.

Stations.—In order that any level may be open to all the compartments of a shaft, it is necessary that the station should be of a width equal to the full size of the shaft. This length is about 20 feet, and it is made high enough to give sufficient head-room for the easy handling of everything which has to be landed.

Ore-bins.—It is now the invariable practice in the larger mines to load the skips from ore-bins. Ore-bins are made either by sinking a

chamber or winze from the back of the station so as to open into the shaft, or by cutting away the angle under the station-floor; in either case the ore-bins open into the shaft at those compartments which are used for hoisting purposes. The ore-bins in the lower levels of the Robinson mine will hold 300 tons, while those at the Crown Reef mine will hold 400 tons. In all the deep-level mines, ore-bins of similar and even larger capacity are being constructed. Where development work and stoping are proceeding along the same level, the ore-bin is often subdivided, in order to keep the ore distinct from the waste-rock.

Working the Mines.

Levels.—In the early days the levels were driven at as little as 30 to 50 feet below the surface, followed by a second level at a depth of about 100 feet, but now they are driven as much as 200 or 300 feet apart. The expense of driving levels is so great that in the interests of economy it is clearly important to keep them as few in number as possible. The practical considerations that put a limit on the amount of backs that can be economically developed by a level are (1) the difficulty, expense and time involved in raising and sinking long winzes, and (2) in handling the ore in large stopes.

The reefs at the levels now being worked are dipping at angles which are too low to allow of the unaided movement of broken rock down the stopes, and consequently a great deal of shovelling is required in order to remove the ore. The drives extend horizontally on the reef-plane, in a direction parallel to the strike. They are usually about 7 feet high and 6 feet wide for a single-track, and 8 feet high and 9 feet wide for a double-track. The drives are usually carried on the reef, so as to expose it as much as possible, in order that some idea of its value may be obtained by sampling. In order that ore and water may travel easily along the drives towards the shaft, it is necessary to give the drives a slight gradient, usually 1 in 100.

Very little ore has been won from adit-levels, because the even nature of the surface does not allow of this cheap method of working.

Driving is either done by hand- or machine-drilling, the latter being used when a rapid rate of development is desired. The rate of progress in driving, where machine-drills are regularly employed, is often over 100 feet per month. In the Ferreira mine during 1896, the average amount driven per month by each rock-drill in the drives was 107 feet. It is usual to run the drives either on contract or with a bonus, the men,

as a rule, preferring the latter system. The bonus is paid for every foot driven above and beyond a footage determined on by the mine foreman as being efficient work. The price paid to a contractor, who has to provide labour, explosives, lights and tram the dirt, is usually £2 7s. 6d per foot. Timbering of the levels, except in preparing stopes, is never necessary at depths greater than 200 feet. The character of the ground does not vary very much.

Winzes.—Winzes are sunk at intervals from one level to another, to prepare the ground for stoping and to secure ventilation. The distance apart at which they are placed varies from 200 to 600 feet. Often a raise is put up to meet the winze, when being sunk. The usual size for a winze is about 4 feet in height and 6 feet in width. Compressed air is frequently used in sinking winzes.

Cross-cuts.—An ordinary cross-cut is of the same size as a drive, but those which are made from the shaft, usually called main cross-cuts, are made larger, common measurements being 7 feet in height by 8 feet in width.

Stoping.—In stoping or breaking down the ore blocked out by drives and winzes, both overhand and underhand methods are adopted. Underhand stopes are in many cases more cheaply worked. Mr. J. H. Johns, in a report on the Pioneer mine, stated that, "where reefs are small and hard, underhand stoping is 20 per cent. less costly than overhand." In preparing overhand stopes, the drives are protected either by stull timbering and lagging, or by leaving an arch or strip of the reef over the main drive, and starting the stope from a small back drive. Breast stoping is also adopted. In the majority of the mines one finds all three classes of stoping adopted.

Where the hanging wall of a reef is unsafe, protection is secured either by means of props of rough timber, by leaving pillars of the ore-body until the stope is about to be abandoned, or, in overhand stopes, by filling in with waste-rock from the foot-wall or hanging-wall. Below the level of oxidation, where the walls of the reef are, as a rule, in excellent condition, very few timbers are required.

The average width of stopes is about 5 feet. At the New Primrose mine, the stopes are as much as 15 feet wide, owing to the large size of the reefs. In the Roodeport district, where the mines are working principally the small and rich South Reef, which is only about 5 inches thick, the average size of the stopes is about 36 inches. Where a reef

dips steeply it is possible to work comfortably in a stope of small width, but where the reef is nearly flat larger stopes are a necessity for economical working.

In consequence of the scarcity of native labour, machine-drills are to a large extent used in stoping, of a lighter class than is employed in driving. Machine-stoping is more expensive, as a rule, than hand-stoping, especially in the matter of explosives.

Explosives.—In the stopes, blasting-gelatine, stated to contain 93 per cent. of nitro-glycerine, is used more than any other explosive. For driving and general development work, gelatine is invariably used.

Labour in the Stopes.—Stopes are usually let on contract. The unit in general use is the square fathom of area of the reef-plane. In order to encourage efficient work, a bonus is given in some mines to the contractor who gets his rock out with the least expense, and also to the one who fills the greatest number of trucks with reef.

Tramming.—Tracks of about 18 inches gauge are laid in all working drives, in order to tram the ore to the shaft. In main cross-cuts, it is usual to lay a double track. The rails, which weigh from 12 to 16 pounds per yard, generally rest on light steel sleepers set in the rubble with which the drive is levelled, but in some mines wooden sleepers are preferred, as they make a firmer track. The trucks, made of steel-plate, have a capacity ranging from 10 to 16 cubic feet. End-tipping or side-tipping trucks are used according to requirements. The labour of tramming is performed by Kaffirs.

On the surface, the greater portion of the transport is done by one or other form of mechanical haulage. The most common form is an endless-rope. At the Crown Reef mine, the ore is transported in trucks drawn by an electric motor, a distance of about 4,500 feet from the main shaft to the mill, in which distance there is a fall of about 70 feet. The transport on this track cost during the year ending March 31st, 1897, at the rate of :—Working cost, 1·461d., and maintenance, 1·947d., or, in all, 3·408d. per ton. During the same period, underground tramming by natives cost over five times the above amount.

Machinery.

Winding.—In vertical shafts, the rock is hoisted either in cages, into which the trucks are run, or in skips. In inclined shafts, it is

hauled either in skips or, if the inclination be low throughout, in the mine-trucks, in which case there are switches between the level and the incline, or flat sheets on which the trucks are turned. Self-dumping skips are largely in use. Skips are made of riveted steel plate from ½ inch to 1 inch in thickness. The skip rails in inclined shafts weigh from 20 to 40 pounds per yard, according to the capacity of the skip, which varies from 1 to 4 tons.

Ropes.—Steel-wire ropes are almost invariably used for winding. It is usual to consider the safe working load of such ropes to be one-fifth of the actual breaking-strain.

Winding-Engines.—The general type of winding-engine employed is a simple, direct-acting, non-condensing double-drum hoist. There are very few compound winding-engines in use. A direct-acting is preferred to a geared winding-engine, because at high speeds there is less wear-and-tear, and also because, with no reducing pinion between them, a drum of less diameter gives as great a speed as a larger drum with a geared engine, and the load acts at a smaller leverage, so that, after starting, the full speed of the engine is more quickly reached. There are very few condensing winding-engines because the work of hoisting is more or less intermittent, whereas a condenser should work regularly. Two drums are used with the direct-acting engines. The engines are usually arranged with twin cylinders, and in incline shafts, have, as a usual size, cylinders about 16 inches in diameter by 48 inches stroke, and the steam-pressure generally varies from 80 to 100 pounds per square inch; under these conditions, an average speed of about 1,000 feet per minute with a full load of 5 tons can be maintained.

At the Jumper's Deep No. 1 shaft, which has one sinking and two main hoisting-compartments, there are two direct-acting winding-engines; one is a double-drum hoist with two twin cylinders, 18 inches in diameter by 48 inches stroke, 22 feet apart and steam-jacketed; it is fitted with two vertical cylinder steam-post brakes, and with outside friction clutches and Corliss valve-gear. The drums are 8 feet in diameter, carrying 2,000 feet of rope, and the engines are designed to hoist a load of 6,000 pounds from a depth of 2,000 feet at a rope-speed of 1,700 feet per minute, the steam-pressure being 120 pounds per square inch. The other hoist is a twin-cylinder, direct-acting, single-drum hoist of about 340 horsepower; the cylinders are each 20 inches in diameter by 48 inches stroke, and they work at a steam-pressure of

120 pounds per square inch. With a steam-pressure of 140 pounds, this hoist could exert over 400 horsepower, capable of raising a load of 5 tons from a vertical depth of 2,000 feet, at a speed of 1,500 feet per minute. The drum is 8 feet in diameter and 6 feet wide; it is fitted with post-brakes; Corliss valve-gear and steam reversing-gear are fitted to the cylinders.

It is proposed in the deep-level mines, where both the vertical depth to the reef and afterwards the inclined depth on the reef are great, to use a separate hoist at the head of the incline shaft just below the bottom of the vertical shaft. As steam is unsuited for transmission to a considerable depth down a shaft, these hoists will probably be driven by electric motors or perhaps compressed air. At the Robinson Deep No. 2 shaft, an electric-driven hoist of 350 horsepower will be placed in this position to work at 110 volts and 280 ampères, the power will be transmitted down the shaft through a 2¼ inches cable at a pressure of 2,300 volts.

Drainage.—The quantity of water met with in the mines is small. Mr William Hall, in his evidence before the Industrial Commission, June, 1897, stated * that for 15 miles of the Central Rand the ruling quantities of water were as follows:—

(1) The outcrop ground yields an average of about 50,000 gallons per shaft per day, the range of amount being from 10,000 to 90,000 gallons, and there are three or four exceptional cases where the amount runs materially higher. (2) That the first row of deep levels, as a rule, yields an average of about 45,000 gallons per shaft per day, the range of amount being from 8,000 to 80,000 gallons, and there are two or three cases of very materially higher water output. And (3) that the second row of deep levels, with one exception, yields from 2,500 to 5,000 gallons per shaft per day only. There is an annual variation in the amount of water-yield, due to alternations of rainy and dry seasons, and cases where decidedly larger flows, by comparison, exist, are of short life.

The bulk of this water is surface-water, which can be collected at shallow depths and pumped to the surface. At No. 1 shaft of the Robinson Deep mine, of 1,500 gallons per hour, about one half is pumped from the 200 feet station, and in No. 2 shaft, of a similar amount, 1,200 gallons are drawn from the 250 feet station. These shafts were sunk to their entire depth, No. 1 shaft to 2,390 feet, and No. 2 shaft to 1,875 feet, without interference from water; when sinking was started, one small steam-pump was arranged at each shaft, and this appliance was used for the surface-water; below this point all water was drawn in skips.

* *The Mining Industry: Evidence and Report of the Industrial Commission of Enquiry* (South African Republic), 1897, page 416.

Where water occurs in depth, it generally comes along a dyke or fault. The ordinary mine-water, as it is pumped from the mine, is generally very impure. Most of these impurities are due to the oxidation of the ore. The water from the Spes Bona mine has been analysed as follows :—

	Grains per Gallon.
Persulphate of iron	13·40
Sulphate of calcium	6·00
Carbonate of calcium	14·00
Sulphuric acid	11·00
Solids	34·18
Matter in suspension	2·87

Pumping-engines.—Cornish pumps are extensively used, especially by the outcrop companies, It is seldom that pumps of more than 9 inches diameter are required. The intervals between the lifts depend upon the power of the engine which is employed. In the deeper levels it has been arranged to use electrically-driven pumps capable of lifting the water against a head of 500 feet, and accordingly the pumps will be placed and the sumps cut at this distance apart. With Cornish pumps, the lifts are usually 300 feet apart. At the Robinson main shaft, all the mine-water from the sixth level is pumped up to the surface by means of an electrically-driven Riedler pump. At the City and Suburban mine, the same amount of work is done by means of a electrically-driven 3-throw pump.

Surface-Equipment of the Mines.

Mining areas on the Rand neither present great natural advantages nor form any considerable difficulties to the laying out of surface-works. With regard to the water required for milling, the heavy rainfall during the summer season affords an ample supply, it being only necessary to retain the water draining from the hill-slopes in large dams, whence it is pumped up to suitably situated reservoirs.

Headgears.—There is naturally a great diversity of design in headgears, arising both from the nature of the shaft to be equipped and from the scope afforded to the preferences and opinions of individual engineers. A large number of the headgears are very elaborate and costly, not only serving the primary purpose of hauling and hoisting plant, but also making provision for ore-breaking and sorting, and embodying storage-bins of large capacity. It is now considered the best practice to raise the ore to such a height above the surface on the headgear that it may

be tipped at once into bins. As the ore is tipped, it falls on to grizzleys, through which the fines pass into bins, whence they are taken to the mill, while the coarse ore falls into other bins, whence it is taken to be dressed. The height, which is sufficient for tipping the ore into bins, also allows the waste to be dumped, and leaves the actual mouth of the shaft clear for a landing-place for men and material.

At a large number of mines, the ore is hoisted to its full height at once, and when it again reaches the surface-level, it has been sorted, crushed, and stored, and is ready for the mill, the ore-bins, crushers and sorting-floor being built on foundations independent of the headgear. At the Ferreira mine, the screening and sorting are done on the headgear, but the ore-breaking takes place in the battery.

Self-dumping skips have been adopted throughout the Rand. The device underlying nearly all arrangements for attaining this object is as follows :—The back wheels of the skips are made two or three times as broad as the front wheels, or a second wheel is keyed on outside of the ordinary wheel. Near the top of the headgear, where the skip is to be dumped, is fixed a pair of rails on to which the back wheels run, while the front wheels, being narrow, continue to run on the inner or shaft-rails. In some cases, the outer rails are set at a higher inclination than the shaft-rails, in others the shaft-rails are bent downward, the result being, of course, the same in each case. Provision is also made for over-winding.

At the Ferreira mine, the wheels of the skip are guided up the shaft, till at the desired point on the headgear they are held on either side in a blind loop fixed to the sides of an iron tumbler, into which the skip has entered, and which is centred near its top, on the tipping side of the headgear framework. The independent motion of the wheels is thus passed on to this tumbler, which turns up until the contents of the skip are discharged. Should over-winding occur, this tumbler is further raised, so that the wheels escape again on the upper side; in this position the tumbler is secured, so that if the rope should break, the skip would fall down on to it, either to be held or to be turned off from the shaft. In the Ferreira headgear, a tumbler is arranged at the surface-level to tip the drills.

The usual height for an incline headgear is about 50 feet. Where, however, sorting and crushing are done at the headgear a greater height is used, generally from 60 to 70 feet. The second row of deep-level mines which have to go to great vertical depths, have higher headgears, that of the Robinson Deep mine being 85 feet high. The diameters of the

pulleys are usually about 8 feet: in the deeper levels, however, they are larger, that of the Robinson Deep mine being 14 feet.

With the single exception of those of the Robinson Deep mines, which are of steel, all the more important headgears are built of timber.

Air-Compressors.—The air-compressors are usually direct steam-driven. The air-cylinders are double-acting, air being compressed during each stroke of the piston. The duplex style of air-compressor is chiefly used. In consequence of the rarefaction of the air at the altitude of Johannesburg (5,600 feet above sea level), the capacity of the compressors is lessened; it is usual to expect them to perform about 84 per cent. of what they will do at sea-level. The horizontal cross-compound type is now being extensively erected. There are several vertical compressors also in use, and although this type costs more initially, with very large engines it is less expensive in wear-and-tear and loss in friction than the horizontal type. There are a few vertical air-compressors driven by triple-expansion steam-cylinders; with these there are two low-pressure and one high-pressure air-cylinders. All the compressors used are dry compressors.

Machine-Drills.—The machine-drills may be divided into two main groups, according to whether the air is distributed by a valve moved by the pressure of air (pressure-valves), or by a valve thrown by some positive movement directly transferred from the piston (tappet-valves). Pressure valves are in greater use, chiefly because there are less breakages with them. The following drills are chiefly used:—Ingersoll-Sergeant, Ingersoll-Eclipse and the Climax. With machine-drills, cross or star-bits and chisel-bits are used. The Blackney furnace is used for heating the drills, and it possesses almost every advantage over the ordinary open forge.

Workshops.—Nearly every large mine includes in its equipment engineering workshops, with a more or less complete outfit of machine-tools. Among other labour-saving appliances adopted is a drill-sharpening machine, by means of which one smith and a couple of boys can finish off from 800 to 1,000 bits a day.

Boilers.—All the ordinary means of retaining and utilizing the heat produced are resorted to, such as feed-water heaters, economizers, and the proper setting and building in of boilers, return-flues and tubes. Owing to the comparative inferiority of locally wrought coal and its

high percentage of ash, it has been found advisable to allow a somewhat larger grate-area than is usual elsewhere, while combustion is promoted by high smoke-stacks, sometimes 150 feet in height, built of steel-plates, and resting on a masonry foundation. The Babcock & Wilcox and the Heine water-tube boiler are in general use.

Ventilation.—During the sinking of vertical shafts, ventilation is effected by bratticing off the pump- and ladder-way with thin planking. When the reef has been reached, and some development has been done, without, however, having effected communication with another shaft, a light galvanized-iron pipe, generally about 2 feet in diameter, is often placed down the pumping compartment, and from it smaller pipes, about 10 inches in diameter, are led to positions as near the ends of the development-drives as possible. In order to assist the air in ascending, this pipe is either taken as high as possible up on the headgear, or it is connected to an exhaust-fan. Where connexion has been made between two or more shafts or openings to the surface, natural ventilation is relied upon, but, in the deep-level mines, efforts are made to assist it artificially.

The average temperature of the strata at a depth of 1,000 feet is about 72° Fahr., and at a depth of 5,000 feet, calculating upon a regular increase, the rocks will have a temperature of about 90° Fahr.

In rising, it is generally considered that 150 feet above the level below is the limit beyond which it is not desirable to proceed, owing to deficiency of ventilation.

Illumination.—On most mines, the shaft-plant includes a dynamo for electric lighting of underground loading-stations, main crosscuts, pumping-stations, and of headgears, sorting-floors, tramways, etc. In stopes, levels, and winzes paraffin candles are universally employed.

Sampling the Reefs.

Sampling.—In most of the mines, samples are taken at regular intervals along all levels, winzes, shafts, etc., where ore is being exposed in the process of development. The set distance between which samples are taken varies from 5 to 20 feet. In addition, samples are taken from the stopes in the producing mines.

Sample Grinding.—This is best done by some form of mechanical crusher, at large mines where there are many samples to get through.

The sampling outfit which gives the best results is a Gate crusher, No. 00, fixed up to break the rock down to ⅜ inch, after which the further reduction necessary to pass the ore through a 60 or finer sieve is accomplished by a Fraser & Chalmers sample-grinder.

Assay-plans.—Mine-sampling records are kept at all the mines, and also assay-plans on which the results of samples taken along the drives, winzes, etc., are placed in proper position.

Averaging Values.—The relative value of a reef, or of a section of a reef, at any point is represented by the multiplication of its thickness into its assay value. Thus the relative value of a piece of banket 10 inches thick and 10 dwts. assay is (10 inches × 10 dwts =) 100 "inches by dwts."

ORE-DRESSING.

Grizzleys.—The spaces between the bars of grizzleys vary from 1 inch to 2 inches, the former space being adopted where very close sorting is to be effected. The inclination given to grizzleys is from 35 to 45 degrees.

Rock-Breakers.—The Gates type of rock-breaker is most in favour. It is customary now to erect rock-breakers in a separate house from that of the mill, either at the headgear or in some position intermediate between the mine and the mill, and to have an ore-sorting plant in the same building. In this way, the rock-breakers can be kept nearer the ground, and are less expensive to erect, while the mill-structure is relieved of some very heavy machinery in an elevated position. Rock-breakers are usually set to crush to a maximum size of about 2 inches cube. In some cases, however, they are set closer, or two are used in series—one breaking coarse, the other small.

Sorting.—The waste-rock picked from the reef-matter is generally quartzite, though in the Nigel district, a good deal of slate occurs in addition. The appliances in use for spreading out the ore may be classed as follows:—(1) Inclined travelling-belts; (2) inclined tables, with a longitudinal reciprocating motion; (3) circular rotating-tables; and (4) simple floors.

It may be said that waste-rock is of necessity worked in every mine. As the value of the gold which would be recovered from clean waste is a negligible amount, it may be considered that each ton of such rock which passes through the reduction-processes incurs an expenditure of about 8s., for which there is no return. Hence the necessity for sorting.

Another advantage of sorting is that the capacity of the mill and the reduction-plants to treat auriferous banket is increased proportionally to the amount of waste sorted out. Mr. J. H. Johns, of the Ferreira mine made the first systematic effort of sorting. The sorting arrangements at the Ferreira mine are as follow:—The skips hauled to the top of the headgear are dumped automatically into two shoots under which trucks are run on a tram-line extending along an upper floor, 60 feet in length. Along the other side of this tram-line are grizzleys, the tops of which are flush with the upper floor, while at the lower end is the sorting-floor, also 60 feet in length by 10 feet in width. On the other side of the sorting-floor, and extending along its whole length, is a series of ore-bins into which the coarse ore is shovelled after it has been sorted. Along the sorting-floor is a second tram-line for waste-rock trucks, the waste being shovelled into these and trammed out to the dumps. Under the grizzleys is another long ore-bin for the fines. The large areas of the grizzley-floor and sorting-floor allow of great freedom in picking, and prevent congestion, since the trucks receiving ore from the mine-skips can be run along the upper floor and dumped at any desired point on to the grizzleys. The amount of waste sorted on these floors is from 40 to 50 per cent of the ore coming from the mine. As long as the assay-value of the waste sorted out is less than that of the residues from the reduction-processes, and the cost incurred in sorting a ton of waste-rock is less than the cost which would be incurred in reducing it, the process of sorting is not being carried too far.

Mill Motors.—Mill-engines of several hundred horsepower are frequent, for besides the stamps and the usual accessories of a battery, such as rock-breakers, concentrators, etc., heavy work in connexion with the water-supply and the driving of hauling systems is in many cases added to the ordinary duties of a mill-power plant. The Robinson power-plant is most complete. The 14 boilers are of the multitubular return type, and 140 horsepower each, equal to 1,960 horse-power. The main driving engine is a tri-compound of vertical marine type, 600 horsepower; the high-pressure cylinder is 19 inches in diameter, the intermediate is 30 inches; and the two low-pressure cylinders are 30 inches each, with a stroke of 42 inches. The high-pressure and intermediate-pressure cylinders work on one crank, and the two low-pressure cylinders on another. The Corliss valve-gear is operated by a governor of the central weight type, the high-pressure cylinder having a range of 0·7. The other cylinders are fitted with hand-adjustable cut-

off gear of the same range. The electric-power is transmitted (1) to the pumping station ¾ mile distant, where there are two sets of 3-throw pumps delivering 50,000 gallons an hour (driven by a 60 horsepower motor); (2) to the pumps in the mine; and (3) to the electric light service throughout the property. There is another Corliss engine 14 inches in diameter by 28 inches stroke; a Rand duplex air-compressor with compound steam-cylinders; and a King-Riedler two stage air-compressor, with a high-pressure steam cylinder 19 inches in diameter, and a low-pressure cylinder 30 inches in diameter: the air-cylinders are 20 inches and 30 inches in diameter, with a stroke of 42 inches.

Metallurgical Treatment.

Milling.—Owing to the simplicity of composition of the ores, and the favourable conditions under which the gold exists in them, comparatively little difficulty is experienced in their metallurgical treatment. Apart from cyaniding, which, in a great measure owes its success to the absence of refractory element in the ore, there is little that is unusual in the metallurgy of the conglomerates. The features of milling that are in any way peculiar are mechanical, rather than purely metallurgical.

No batteries are now erected with stamps of less than 950 lbs. The general average drop given to the stamps is 8 inches, with a speed of from 95 to 100 drops a minute. The average rate of crushing is about 4½ tons per stamp per day. Frue-vanners are used for concentration.

Slimes.—The treatment of slimes is carried out on a large scale.

Cyanide Works.—The cyanide-plant at the Robinson mine is capable of treating 6,500 tons of tailings per month. The pulp leaving the mill is elevated by a bucket-tailings wheel, and the sands are collected by means of a distributor in intermediate vats, whence they are transferred to the treatment-vats. The process in use is the MacArthur-Forrest, the gold-solution being precipitated by means of zinc-shavings. The extraction is 70 per cent. The residues after treatment assay 2 dwts. The consumption of potassium cyanide is 0·5 lb. per ton of ore treated. The working costs, exclusive of royalty, are about 3s. per ton.

Labour, Etc.

White Labour.—The class of white labour available is very high, as might be expected when the inducements offered are considered. The climate is excellent, the fields are of proved permanence, wages are good,

and there is a further inducement in the conditions of work, the amount of manual labour falling to the lot of the white hands being reduced to a minimum, owing to the employment of natives.

The following is a list of the average monthly wages for various occupations at the mines of the South African Republic for the month of December, 1898.*

	Per Month. £	s.	d.		Per Month. £	s.	d.
Managers	96	7	3	Pump-men	25	9	4
Mine-overseers	41	18	7	Stokers	20	9	10
Battery-managers	41	16	3	Carpenters	25	17	3
Other overseers	25	7	0	Blacksmiths	26	17	9
Mechanical engineers ...	43	4	6	Fitters and mechanics ...	26	3	5
Surveyors	31	0	7	Painters	21	11	10
Draughtsmen	28	2	7	Masons	26	2	5
Electricians	26	9	11	Labourers	16	18	1
Secretaries	36	3	10	Assayers	28	9	1
Mine-clerks and storekeepers	22	3	8	Amalgamators	23	14	8
Gangers or shift-bosses ...	31	10	1	Cyanide-workers	24	6	11
Miners and trammers ...	22	13	10	Concentrate-workers ...	20	14	9
Machine-drillers	30	9	3	Vanner-workers	20	12	6
Pitmen	19	5	1	Smelters	27	13	4
Engine-drivers	26	9	1	Sundry workers	20	17	2
Greasers	17	19	6				

Although the wages of white workmen are much higher than in other mining centres of the world, the cost of living is more than proportionately high, and comforts experienced elsewhere are to a great extent wanting. The high cost of living bears especially upon the married man, for with a wife and two children it has been estimated that the cost of the necessaries of life amounts to £19 per month, which leaves little for life-insurance, education, furniture, amusements, etc. In consequence, the greater portion of the married men do not bring their families into the country. The mining companies, in all cases, provide quarters for their employées.

Native Labour.—All purely manual labour is performed by natives. The wages are high, averaging £3 per month, and in addition the native is supplied with food, chiefly mealie-meal. The efficiency of native labour is at the present time much impaired by drink, due in a great measure to the indiscriminate granting of licenses. Quarters, termed compounds, are provided on every mine for the natives employed, and the mine staff generally includes a compound-manager, who is responsible for the maintenance of discipline, the sanitary condition of the compound, and the welfare of the natives generally.

* *Report for the Year Ending December 31, 1898, as presented by the State Mining Engineers to the Government of the South African Republic*, Statement 7.

Stores.—The following is a short statement of the prices of the principal stores on the Rand :—

	£	s.	d.
Coal, Transvaal, per ton of 2,000 lbs.	1	0	0
Gelatine, per case of 50 lbs.	4	18	6
Fuse, per coil of 25 feet	0	0	5
Cyanide of potassium, per lb.	0	0	11
Zinc for cyanide process, per lb.	0	0	8
Candles, per box of 25 lbs.	0	10	6
Mining-timber, poles, per 1 inch in diameter and per foot of length	0	0	9
Timber, deals, 9 by 3 inches, per running foot	0	0	7
,, Oregon pine, 9 by 3 inches, per running foot ...	0	3	0
,, pitchpine, 9 by 3 inches, per running foot ...	0	4	0
Drill steel, per lb.	0	0	5
Iron, per lb.	0	0	2
Galvanized iron, per running foot	0	0	6

Engines, machinery, etc., imported from Europe are about 100 per cent. dearer in the Transvaal than in Europe, owing principally to the heavy railway-charges from the coast.

In conclusion, the writer would like to state that there is not any doubt but that the deep-level mines will continue to pay dividends for at least 40 years to come.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE, OCTOBER 14TH, 1899.

MR. WILLIAM ARMSTRONG, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on September 30th and that day, and of the Council of The Institution of Mining Engineers.

The following gentlemen were elected, having been previously nominated :—

HONORARY MEMBER—

Mr. GEORGE CLEMENTSON GREENWELL, Mining Engineer, Duffield, Derby.

MEMBERS—

Mr. IRVING ARGUS BACHMAN, Consulting Chemical and Mechanical Engineer, Nazareth, Northampton County, Pennsylvania, United States of America.

Mr. JOHN BAKER, Mining Engineer, 165, Fenchurch Street, London, E.C.

Mr. WILLIAM JOHN BAWDEN, General Manager, New Bultfontein Diamond Mining Company, Limited, Beaconsfield, South Africa.

Mr. THOMAS WILSON BRACKEN, Civil and Mining Engineer, Lagos Government Railway, Lagos, West Africa.

Mr. ARTHUR THORNTON CHAMPNEYS, Mining Engineer and Mine-manager, Natal Spruit Gold-Extraction Works, Transvaal, South Africa.

Mr. CHARLES HERBERT CRONE, Mining Engineer, Killingworth, near Newcastle-upon-Tyne.

Mr. JULIAN R. DELMAS, Mechanical Engineer, Success Villa, Assensole, Bengal, India.

Mr. JAMES DOUGLAS, Metallurgist, 99, John Street, New York City, United States of America.

Mr. MARTIN FISHBACK, Mine Superintendent, Ward, Boulder County, Colorado, United States of America.

Mr. ROBERT HANN, Jun., Mine-manager, San Domingos Mines, Mertola, Portugal.

Mr. JAMES SPENCER HOLLINGS, Coke-oven and Bye-Product Recovery Engineer, Brymbo, near Wrexham.

Mr. FREDERICK J. HORSWILL, Mining Superintendent, 1218, Chestnut Street, Oakland, California, United States of America.

Mr. JOHN WILLIAM HUTCHINSON, Mining Engineer, Willow Lodge, Abram, near Wigan, Lancashire.

Mr. GEORGE MACFARLANE, Mining Engineer, Charters Towers, Queensland, Australia.

Dr. GUSTAAF ADOLF FREDERIK MOLENGRAAFF, State Geologist, P.O. Box 436, Pretoria, Transvaal, South Africa.

Mr. J. L. C. RAE, Manager, Sydney Harbour Collieries, Balmain, Sydney, New South Wales.

Mr. AUBREY PERCY WILSON-MOORE, Civil and Mining Engineer, c/o Sheba Queen Gold and Exploration Company, Limited, 33, Old Broad Street, London, E.C.

Mr. WILSON WORSDELL, Chief Mechanical Engineer, North Eastern Railway Company, Gateshead-upon-Tyne.

ASSOCIATE MEMBERS—

Mr. PHILIPPE DAVIDSON AHIER, Idaho Mines, Three Forks, British Columbia.

Mr. WILLIAM SCOTT BARRETT, Abbotsgate, Huyton, Liverpool.

Mr. DENIS RIPLEY BROADBENT, 26, Great Russell Street, Russell Square, London, W.C.; and Royal Societies' Club, London, S.W.

Mr. LOUIS DAVIDSON, Engineer, 8, Burdon Terrace, Newcastle-upon-Tyne.

STUDENTS—

Mr. JAMES MALCOLM MACGREGOR, Mining Student, Cowpen Colliery Office, Blyth.

Mr. JOHN ETHERINGTON MILBURNE, Mining Student, Collingwood Street, Coundon, Bishop Auckland.

The following paper by Mr. R. Harle on an "Automatic Sprayer for Preventing Accumulations of Dust in Mines" was read as follows :—

AUTOMATIC SPRAYER FOR PREVENTING ACCUMULATIONS OF DUST IN MINES.

BY R. HARLE.

The appalling results of explosions and the dangers of dust in mines and other places being recognized, and extended knowledge having been gained by recent experiments and observations, the highest importance must be attached to the prevention of accumulation and methods devised for decreasing the danger. It is admitted and proved beyond doubt, where explosions have taken place, that the explosive force and flame is most destructive in the main galleries, where the newly-made dust is being continually carried; and the destructive violence of the explosion over long lengths of haulage-roads delays the progress of restoring the ventilation and of introducing fresh air into the mine.

The results of experiments carried out by different committees also prove that serious explosions may take place from dust alone; and that we must treat the mines where this element is found or carried with as much care as a powder-magazine. Apparently reliable tests show that dust-explosions and flame have travelled over intervening places of the roadway, which have been watered and damped. This proves how sensitive coal-dust is to explosion, and how desirable it is that we should provide for its removal before it is carried along the roadways.

Many attempts have been made to water or damp the dust lying on the roads, walls and timbers in coal-mines, but, on the principle that "prevention is better than cure," it is now proposed to avoid the necessity of watering the roadways or other parts of the galleries, by preventing any accumulations. (This, of course, will not avoid the damping of dry places when a shot is to be fired, as required by the Coal-mines Regulation Act.)

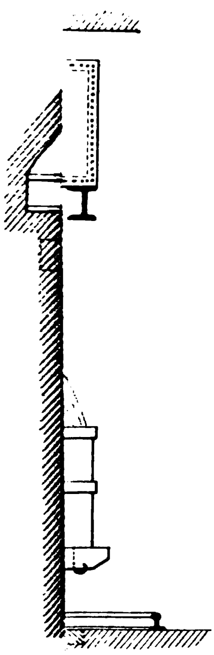
An arrangement has been perfected for slightly wetting the coal and dust on the top of each tub as it leaves the siding in mines, where the engine-setts run at a high speed against strong currents of air, and the same arrangement can be applied to dust at the screens and coal-stores, and to pulverized coal to be sent to coke-ovens, where explosions and accidents have taken place from dusty coal.

The newly-devised method for obviating and diminishing risk to life from coal-dust explosions consists of a system of watering so as to moisten dusty coal on the tops of tubs, after being filled, and before it is carried to the main haulage-roads in mines, and there exposed to the air-currents in its transit to the shaft. The arrangement consists of a means of automatically damping each tub, so as to prevent the escape of dust, and to moisten it to the same extent as in damp mines. In such mines no trace of dust can be found, and few explosions (if any), either from shot-firing or dust, have taken place, and this safety, under such conditions, confirms the theory that damping is effectual in mitigating the effect of coal-dust explosions.

The apparatus (Figs. 1, 2, 3, 4 and 5, Plate IV.) should be fixed at the outer-end of the siding, or at any point in-bye, preferably at the flats or landings, where the tubs are arranged to start on their journey to the shaft. It consists of a perforated pipe or sprayer, *F*, a valve, *E*, and an automatic arrangement, *A*, which opens the valve, *E*, and allows water to spray over the area of each tub, *I*, as they pass under the apparatus. A small tank or cistern, *G*, which can be filled, from any natural supply of water, or by means of a hand-pump, is placed at such a level that the water will run from it through the pipe, *H*, to the sprayer, *F*. The valve, *E*, of the sprayer is actuated preferably by the tub-wheels passing over a projection, *A*, in the rails of the haulage-road, or by some other part of the tub. The tappet, *A*, is placed between the ends of two adjacent rails, *a* and *b* (Figs. 3, 4 and 5, Plate IV.), and between the fish-plates, *c*. When the tub passes this point, the wheel presses down the tappet, *A*, thereby working the levers, *B*, *C* and *D*, which open the valve, *E*, thus allowing the water to pass through the sprayer, *F*, and upon the coal in the tub, *I*.

It has been found in practice that about 1 pint of water, sprayed over each tub, is sufficient to moisten the dust, and prevent it from rising, so that a tank containing about 70 gallons is sufficient to moisten an output of about 150 tons per day.

The method of applying the automatic water-sprayer in a coal-drawing shaft is shown in Figs. 6 and 7 (Plate IV.). The tappet, *A*, is pressed inward, when the cage is passing the apparatus (Fig. 6), and actuates the levers, *B*, which close the valve, *E*, and so prevent water from falling upon the cage. When the cage passes above the tappet, *A*, it falls back to its former position, opens the valve, *E*, and allows the water to pass to the sprayer, *F*. *H*, is the water-supply pipe.



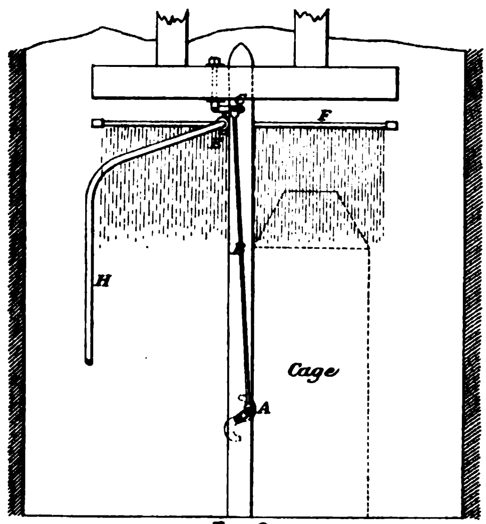
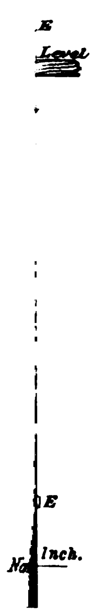


Fig. 6.



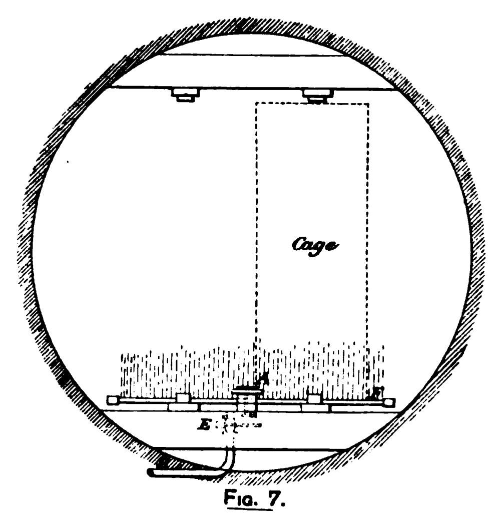


Fig. 7.

Scale, 3 Feet to 1 Inch.

The automatic water-sprayer may be applied to a tub-tippler, *K*, as shown in Figs. 8 and 9 (Plate IV.). The pin, *A*, is fixed to the axle, *J*, of the tub-tippler, *K*, it actuates the levers, *B* and *C*, when the tub-tippler is worked, and simultaneously opens or shuts the valve, *E*, which regulates the supply of water to the perforated pipe or sprayer, *F*. The sprayer, *F*, distributes the water over the coal as it falls from the tub upon the screen. *H*, is the water-supply pipe.

The automatic water-sprayer is in use at the Browney and South Brancepeth collieries, in the mines; it is also applied in the shafts to catch the dust there, and to prevent it from passing in-bye; and at the screens aboveground.

The advantages of the automatic water-sprayer are as follows:—(1) The arrangement can be made and fitted at a small cost and is worked automatically. (2) The dust is secured before it meets the air-currents, and is carried direct out of the mine. (3) It obviates the danger of dust accumulating on the timbers and walls of the galleries, and prevents it from being carried in-bye to the working-places. (4) In case of a gas-explosion, it will prevent damage to the roadways and air-crossings, and will greatly minimize the loss of life, and enable fresh air to be speedily introduced into the mine. (5) Its use causes no damage to wire-ropes or to the roadways. (6) It prevents another source of dust, which is found at the screens aboveground, and prevents dust from passing down the pit. (7) The coals are again moistened at the tub-tippler or screens when tipped, and this additional moistening prevents dust-accumulations on the surface. (8) There is no waste of coal or dust in screening and conveying coal to the coke-ovens, and explosions in the ovens and other places aboveground are obviated.

REFERENCES TO PLATE IV.

A, tappet; *B*, *C* and *D*, levers; *E*, valve regulating the water-supply; *F*, perforated pipe or water-sprayer; *G*, water-tank; *H*, water-supply pipe; *I*, coal-tub; *J*, axle; and *K*, tub-tippler.

Mr. A. L. STEAVENSON (Durham) said that the paper treated the coal-dust question from an entirely new point of view, for by means of the automatic sprayer coal-dust was prevented from accumulating, which was very different from moistening it before firing a shot. It was evidently much better to damp the coal before it left the flat or

siding than to try afterwards and prevent an explosion while shot-firing. Prof. Dixon, in one of the early volumes of the *Transactions* of The Institution of Mining Engineers, stated that if coal-dust was only damped to a slight extent they were doing more harm than good, because the explosive properties of dust were enhanced by adding steam to it, as combustion or explosion could only occur between certain limits of moisture. Prof. Dixon stated that :—

In the detonation of carbonic oxide in a long tube, the oxidation is effected indirectly by means of steam, as it is in the ordinary combustion of the gas. Measurements of the rate of explosion of carbonic oxide and oxygen in a long tube showed that the rate increased as steam was added to the dry mixture, until a maximum velocity was attained, when between 5 and 6 per cent. of steam was present.*

He suggested that the present Mines Regulations Act was really injurious, and it should be enacted that there should be wet lengths of wagonway, so that the air in passing would acquire moisture and prevent an explosion from spreading. As a rule, when an explosion reached a length of wagonway, which was thoroughly wet, it stopped there, and he thought that the only advantage to be derived from using water down the pit was to prevent the spreading of an explosion. In order to prevent coal-dust from igniting it was necessary to introduce about 50 per cent. of water, as dust must be so wet that water would drop out of it when the hand squeezed it.

Mr. P. KIRKUP (Birtley) said that he fully appreciated the idea of damping the dust, but it seemed to him that this paper rather advocated a system of wetting coals, which from an economical standpoint might be considered as disadvantageous to the owner. The workmen were paid for coals as they came out of the mine, and if water was added so as to appreciably increase the weighing of the coal on the pit-bank, there would be a loss of weight due to evaporation of the water, between the pit-bank weight and the sales weight.

Mr. A. L. STEAVENSON replied that the application of 1 pint of water to ½ ton of coals would not do a great deal of harm, and if by so doing they could prevent an explosion, the payment for the little moisture which was added to the coal would be well recouped.

Mr. C. C. LEACH (Seghill) suggested that by putting the water on the tub they would save a weight of dust from being blown from the tub equivalent to the water used.

* *Trans. Inst. M.E.*, 1892, vol. iii., page 317.

Prof. H. LOUIS (Newcastle-upon-Tyne) said that this system appeared to involve a possible source of danger. If he had followed the paper rightly, the writer suggested that the coal should be damped before it left the station or flat, and that, therefore, the coal would commence travelling in a damp state along the main travelling-way, meeting as a general rule the intake air; and the result would be, of course, that the water which had been sprinkled on the coal would gradually vaporise and probably by the time the truck got near to the shaft would have entirely evaporated, so that by this method they would be transferring the danger arising from dust from a point near the working-face, where safety-lamps were used, to another point near the shaft, where very probably naked lights might be in use. Unless the method was combined with some form of sprinkling on the main travelling way, he was inclined to think that it might be accompanied by the danger which he had indicated.

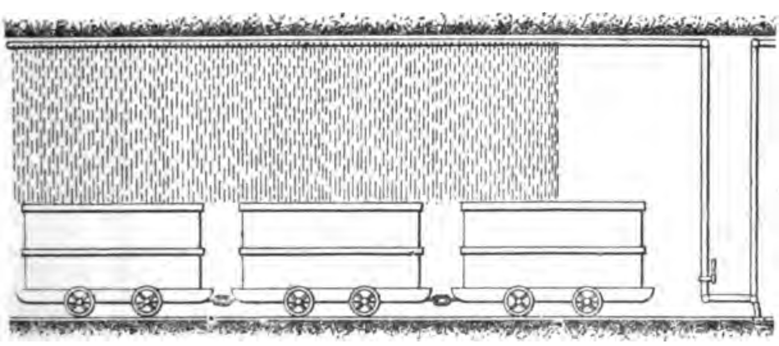


FIG. 10—SIDE VIEW. SCALE, 4½ FEET TO 1 INCH.

Mr. T. L. ELWEN (Brandon) asked whether the tubs were sprayed once only during the journey, and also what was the condition of the coal on the top of the tubs when they reached the shaft. In his experience, where the sets had to run a considerable distance the jolting of the tubs disturbed the wetted cake on the top so much as to render it useless.

At Brandon colliery, a water-spraying arrangement was in use, and was not very dissimilar to Mr. Harle's. A water-sprayer, consisting of a perforated iron pipe 1½ inches in diameter and 12 feet long, fed by water brought from the surface, with a head of 500 feet, is placed at the offtakes on the engine-plane, and is brought into action by the off-take-boy turning a tap and allowing the water to run on to the tubs during the time that the set passes by (Figs. 10 and 11). Two of such sprayers are in use for journeys from 1 mile to 2½ miles in length. Each sprayer

uses ½ pint of water per tub. The velocity of the set of tubs is about 13 miles per hour. The use of this arrangement has reduced the quantity of dust deposited in the engine-planes, but still there is sufficient left to necessitate the practice of regular watering from the supply-pipes continued along the engine-planes.

Coal-dust is also raised by the running of the empty tubs when going inbye. The crevices within the tub are filled with dust, which is jostled out and raised into the air-current on going inbye. He should be glad if Mr. Harle would say whether any provision was made for laying this dust.

The arrangement of sprayers at the surface was commendable, and no doubt could prevent a large quantity of dust from going down the pit, to say nothing of the "muckle saved muckle gained," and a care for the farmers' crops.

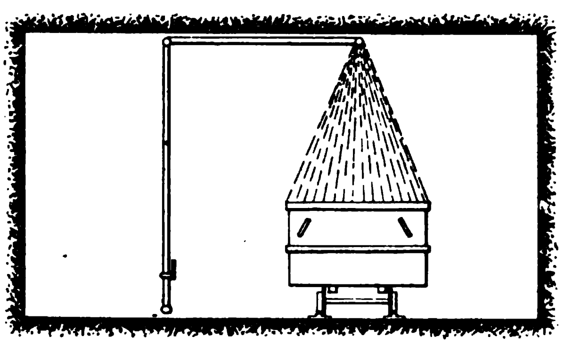


FIG. 11.—END VIEW. SCALE, 4½ FEET TO 1 INCH.

Mr. R. HARLE, replying to the discussion, wrote that he found after using the automatic water-sprayer at the collieries under his charge for about two years that the method was effectual in preventing dust-accumulations and avoided the continual watering and cleaning of the roadways, which previously was a heavy item of cost. He might add that, for some time after using the water-sprayers, he found in places where the thill had been softened and damaged by the continual watering of the roadways (the system previously in use), that the stone dust from the thill continued to rise for some time until the floor regained its previous hard state. This may be the source of dust referred to by Mr. Elwen—dust raised by the travelling inbye of empty tubs. He always found that this happened where the system of "watering" the roads was employed, and that as soon as they dried the coal-dust which had been deposited together with the thill dust was raised and mixed with the air-current on the passage of a set of tubs.

He found that there was no need for further damping of the tubs after starting on the outward journey, but if, owing to the varying conditions, more watering was needed, another sprayer could be fixed at any point between the landing and the shaft, or the valves of the inbye sprayer could be so regulated as to give the necessary additional quantity of water required to secure the dust.

Above ground, where he had for some years specially prepared the coal to a fine mealy substance used for coking purposes, he found the damping at the screens secured the dust and reduced the waste and danger to a minimum; and further, the damping during conveyance of this small coal to the storage-hoppers and coke-ovens prevented it being blown away in windy weather and also obviated the risk of an explosion when discharging the dust into hot coke-ovens.

The PRESIDENT (Mr. W. Armstrong) moved a vote of thanks to Mr. Harle for his paper, and the resolution was cordially approved.

DISCUSSION ON MR. H. G. STOKES' PAPER ON "THE ORE-DEPOSITS OF THE SILVER SPUR MINE AND NEIGHBOURHOOD, TEXAS, QUEENSLAND."*

Mr. H. G. STOKES wrote pointing out a few errata in his paper:— Page 275, line 8, should read, "merge laterally into beds"; page 276, line 19, "up to 14 per cent. of copper"; page 277, line 25, "isolated patches of ore being met with"; page 279, line 29, "the joints and bedding-planes in the shale are lined with steatite"; page 280, line 32, "the two ore-bodies touched each other"; page 281, lines 22 and 24, "carbonate of zinc"; and page 283, line 35, "exclusively to the argillaceous shales." He had also detected the following errors in Plate VI.:—In the plan (Fig. 2) showing the outcrops of ore-bodies, the "No. 3 shaft" on the eastern side of the ore-bodies near the slide, in right hand top corner, should be "No. 5 shaft"; and it was unfortunate that the draughtsman had made the ore-bodies strike at almost right angles to the correct course, namely north-west instead of to the east of north. In Fig. 5, "No. 3 ore-body" had been marked "No. 2 ore-body"; and "No. 2 ore-body" marked "No. 3 ore-body."

A paper by Mr. SIDNEY BATES on "The Driving of a Stone-drift at the West Wylam Collieries" was read as follows:—

* *Trans. Inst. M.E.*, vol. xvii., page 274.

THE DRIVING OF A STONE-DRIFT AT THE WEST WYLAM COLLIERIES.

By SIDNEY BATES.

The Mickley Coal Company's collieries are situated about ¾ mile west of Wylam Station on the Newcastle and Carlisle Railway. The royalty owned and under lease extends from the river Tyne on the north to the 90 fathoms dyke on the south.

The seams of coal worked are those of the Middle Coal-measures (Geological Survey) from the Towneley to the Brockwell seam. This is the lowest workable seam in this district, with the exception of a seam of cannel (of very limited area) found in the Gannister and Millstone Grit series, about 84 feet below the Brockwell seam.

The strata along a north-and-south line, from the river Tyne to the 90 fathoms dyke, form a syncline and anticline, as shown (Fig. 1, Plate V.). It will be seen that there is a denuded area, with a breadth of about ¼ mile and a length of 2 miles.

The seams on the syncline are worked by means of the shaft, *A*, and on the anticline by means of a level drift (from the surface), *A B*, which is about 1¾ miles in length. From the point, *B*, the strata rise southward about 5 degrees. The whole of the output is run to the point, *B*, by means of self-acting inclines. The seams can be wrought only to the point, *C*, which is at present the lowest level, the strata dipping south 10 degrees from this point.

It has been found expedient to continue the level drift from the point marked, *B*, (Fig. 1), so as to cut the coal-seams at, or as near as possible to, their lowest point, *D*, which was reached after drifting about 5,145 feet. As well as winning out a considerable area of coal for the West Wylam colliery, this drift will drain the seams to the extreme western boundary of the royalties worked by the Mickley collieries.

Before commencing an undertaking of such magnitude, the various methods of drifting were considered, namely, hand-drilling and compressed-air and electric drilling-machines. Each of those methods possess certain advantages and disadvantages, which received due consideration. Hand-drilling would have been most economical as far as cost of plant was concerned, but, expedition being required in this case, its use was out of the question.

The mine being non-gaseous, electricity received prior consideration, and the rapidity with which the cables could be carried forward was of some moment. Dynamos, motors, and drilling-machines were tried at the works of electrical engineers; but the type of rotary drill exhibited was not considered of sufficient power to penetrate some of the strata through which the drift must pass. The hardness might possibly necessitate the employment of diamond drills.

However, compressed air was employed to drive the drills; and although often abused for low efficiency, it had given entire satisfaction during the work.

The installation consisted of an air-compressor, an air-receiver, and 3 Cranston rock-drills. The Cranston air-compressor had a steam-cylinder 16 inches in diameter and 20 inches stroke, with an air-cylinder 18 inches in diameter and 20 inches stroke: the cylinders were placed parallel to each other with a heavy fly-wheel between them. The air-cylinder was surrounded by a water-jacket, and there were four inlet- and two outlet-valves at each end of the cylinder (Figs. 2 and 3, Plate V.). Steam was used at a pressure of 80 pounds per square inch, and compressed the air to a pressure of 60 pounds per square inch. The air-receiver was 4 feet in diameter and 13 feet long. The air-compressor was fixed at the surface, about 1¾ miles from where the drift, *B D*, was commenced, the air being conveyed in 4⅞ inches metal pipes, fitted with the Forster joint and an indiarubber ring, *a*, (Fig. 4, Plate V.), with the exception of about 240 feet near to the face, where steel pipes, about 30 feet in length, were used (Fig. 5, Plate V.). The metal pipes were quickly laid, and there had not been more than one or two instances of a blown joint during the five years of working. The steel pipes, in 18 feet lengths, were opened at the ends so as to form small flanges, after 2 loose rings had been slipped on the tube. The loose rings were made with a spigot and faucet, which was drawn together by 4 bolts, and thus made to enclose an india-rubber ring, *a*, between the two pipes (Fig. 5, Plate V.).

The drift was commenced in September, 1894, and let to the ordinary stonemen of the colliery, 6 workmen and 3 assistants being employed *per diem*, 2 men and 1 assistant working in each 8 hours shift.

The drift was driven 11 feet wide and 6½ feet high, with an area of 71½ square feet. The workmen contracted to drive the drift, find all explosives, and set all timber where necessary. The drift was driven for some distance before the machinery was fixed and in working order; and

the workmen did remarkably well with ordinary ratchet-drills, driving about 60 feet per fortnight.

The strata passed through did not vary much from those above the Brockwell seam. A section of the strata passed through in this drift is given in Appendix I. With the exception of very hard compact siliceous sandstone (in texture approaching quartzite) and a small vein, about 6 inches wide, filled with galena and kaolinite, no mineral of note was observed. The galena was found to contain a low percentage of silver.

The Cranston percussive drilling-machine is shown in Figs. 6, 7 and 8 (Plate V.). The air-cylinder was 4 inches in diameter by 5¾ inches stroke. With an average air-pressure of 55 pounds per square inch, the rock-drill made 400 strokes per minute. Fig. 6 exhibits a longitudinal section, and Fig. 7 a cross-section through the collar-head of the piston-rod. The rock-drill is speedily raised and lowered on a pedestal (Fig. 8, Plate V.) by means of a ratchet-lever to any desired position. The drill is fitted with a universal movement, *a*, and the machine can be fixed to drill at any angle. The drilling-machines are strong, and as they had no complicated parts, the workmen soon become accustomed to their use: the cost of repairs was very low.

The drills commenced with a diameter of 3⅝ inches, and diminished by three or four successive sizes to 2⅛ inches in diameter. The full depth of holes bored in blue metal (shale) was in some cases 8 feet. The depth of holes bored in harder stone was less, and varied considerably according to the position of joints, etc. Only two forms of drill-bits were used, namely, the cross-bit and X-bit, but after a time the workmen found that the former pattern gave the best results.

The Cranston machine was hand-fed, and where the strata changed frequently the writer found that hand-fed machines were most efficient, as the workmen could regulate the feed to suit the nature of the stone. Drills, which advance automatically, had been used in some cases, but as a rule nowadays the automatic feed had been almost discarded.

The mean length of drift driven *per diem* averaged 3·72 feet, at a cost of 18s. 2d. per foot; and the cost, including cost of machinery after allowing for value, when the drift was finished, had been £1 per foot.

When driving through strata of an argillaceous and shaley nature, the workmen ceased to use power-drills, as they found, in moderately hard stone, that they could drill the holes as speedily with the ordinary hand ratchet-drill, on taking into consideration the time required to fix the machine-drill.

The general position in which the holes were drilled is shown in Figs. 9 and 10 (Plate V.). The centre and sumping-holes were ignited first, the position being changed according to the rise or dip of the strata. Where the strata were rising, the leading or sumping holes were bored in the bottom, and in the top, where the strata were dipping.

The number of holes varied from round to round—in blue metal 10 to 13 holes were sufficient; whilst in harder stone the number was greater. The greatest depth bored in one shift by two machines was 80 feet.

Where the stone was sufficiently damp to make the borings plastic, some difficulty was experienced in keeping the holes clear; and to overcome this, a small close cistern was used, mounted upon wheels, and provided with two taps, which could be connected, one to the air-pipes and the other to a hose of sufficient length to reach to the drill-holes. The pressure of the air upon the water in the close cistern forced a jet of water out with great velocity, which speedily cleared the holes.

To facilitate the work, it was arranged for one set of men to do the drilling, and the following set to blast and fill the stones into the tubs to be sent to the surface. Where hard strata were met with, two shifts of men were required to drill the holes, and the third shift fired the shots and filled the stone.

The drift could have been driven more expeditiously, but, as the large quantity of stone had to be conveyed to the same heapstead as an output of 1,200 tons of coal per day, it was difficult to increase the number of men without interfering with the ordinary working of the colliery. After reaching a distance of about 2,500 feet, the work performed per day diminished.

The explosives used were compressed powder and gelignite, but mostly the former. The cartridges were 1⅝ inches in diameter and weighed about 3½ ounces. The charge placed in each hole varied from 2 to 6 pounds, according to the length of the hole and the nature of the strata. The round of holes were all charged together, the sumping and centre-holes being fired first. An electric shot-firer was used and simultaneous firing tried, but without success. Theoretically this system is a misconception, and even if the charges ignited simultaneously, the result is not as efficient as with independent firing. The object of igniting explosives in a rock is to disintegrate it with a reasonable, if not the least, weight of explosive. If all the shots are ignited at once we cannot expect that one shot will help the other; but, if the centre charges are fired first, so as to loosen the middle of the working-face,

the side charges should then operate under the most favourable circumstances.

The volume of rock excavated from the drift (5,145 feet long and 71½ square feet in area) was 367,867½ cubic feet, and the explosive used was 6·4 pounds per linear foot or 0·09 pound per cubic foot.

The drift was ventilated by means of a 4½ inches brick partition-wall built 3½ feet from one wall-side, and carried to within 150 feet of the face. The fresh air was passed along the wider side of the brick brattice, and carried beyond the end (closed by a door) to the face by means of wooden boxes (24 inches by 24 inches). The return air passed out of the drift, along the narrower side of the brattice. Compressed air was allowed to escape at the face, so as to clear the smoke quickly out of the drift, after firing shots. The temperature of the air at the face of the drift was about 61½° Fahr.

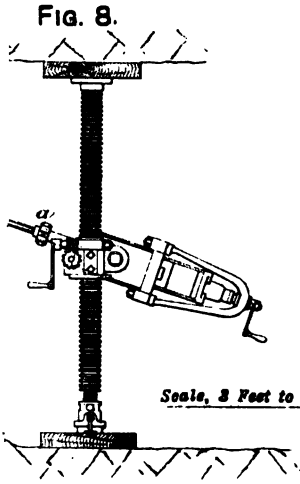
APPENDIX I.

SECTION OF STRATA PASSED THROUGH IN DRIVING THE MAIN LEVEL DRIFT AT WEST WYLAM COLLIERY.

No.	Description of Strata.	Ft.	In.	Thickness of Strata. Ft.	In.	Total Depth below Brockwell Seam. Ft.	In.
	Brockwell Seam—						
1	COAL ...	1	11				
2	Splint ...	0	6				
3	Seggar-clay	1	8				
4	COAL ...	1	6				
		—		5	7	—	
5	Blue metal			2	0	2	0
6	Clay, mixed with ironstone			2	0	4	0
7	Post, with grey metal partings			17	9	21	9
8	COAL			0	6	22	3
9	White post			6	0	28	3
10	COAL			0	4	28	7
11	Blue metal			1	0	29	7
12	COAL			1	0	30	7
13	Blue metal			1	0	31	7
14	Grey post			1	9	33	4
15	Blue metal			4	0	37	4
16	COAL			0	6	37	10
17	Blue metal			6	0	43	10
18	Seggar-clay			0	6	44	4
19	Blue metal			4	6	48	10
20	Blue metal and post girdles			5	6	54	4
21	COAL			0	7	54	11
22	Blue metal			0	6	55	5

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Total Depth below Brockwell Seam. Ft.	In.
23	Seggar	0	9	56	2
24	Blue metal mixed with post	3	6	59	8
25	Seggar	2	6	62	2
26	Blue metal	3	0	65	2
27	White post	5	0	70	2
28	Blue metal	1	9	71	11
29	COAL	0	9	72	8
30	Seggar	1	0	73	8
31	Blue metal	6	9	80	5
32	White post	16	6	96	11
33	Blue metal	3	6	100	5
34	Grey post	12	0	112	5
35	Blue metal	1	0	113	5
36	White post	1	0	114	5
37	Blue metal	0	9	115	2
38	Grey post	10	0	125	2
39	Very hard siliceous sandstone	15	6	140	8
40	COAL	0	9	141	5
41	White post	26	0	167	5
42	Blue metal	5	6	172	11
43	Grey post, with blue metal partings ...	4	6	177	5
44	Blue metal, with post girdles	27	9	205	2
45	White post	5	0	210	2

Fig. 8.



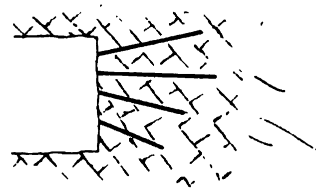


Fig. 9.—Section.

Scale, 10 Feet to 1 Inch.

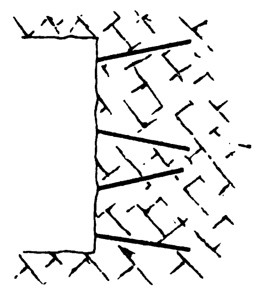
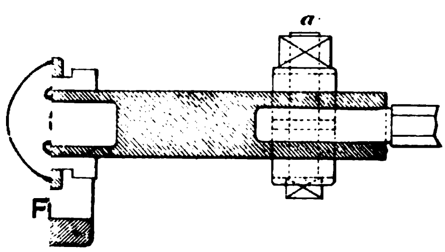


Fig. 10.—Plan.



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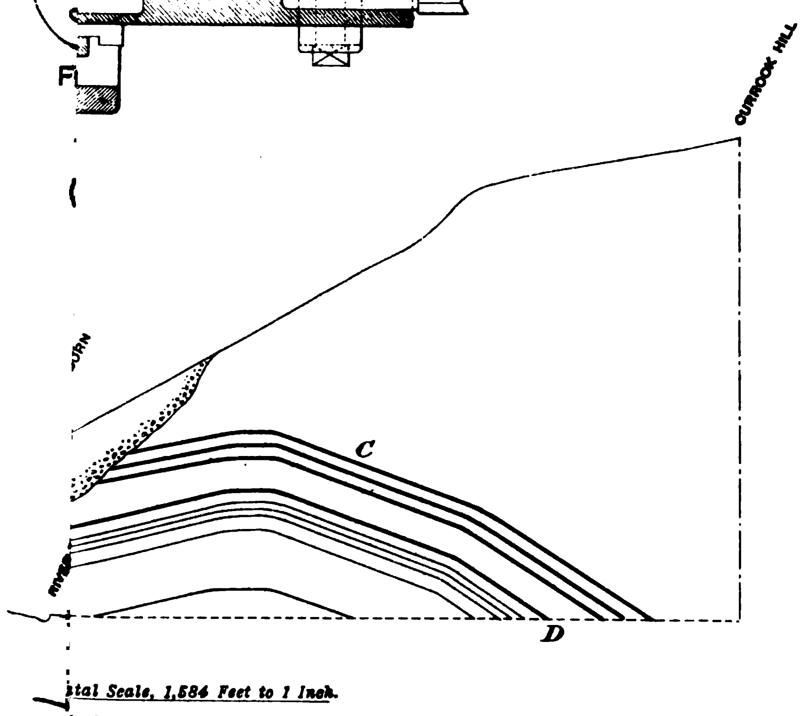

...tal Scale, 1,584 Feet to 1 Inch.

...ical Scale, 800 Feet to 1 Inch.

Nor

Prof. H. Louis (Newcastle upon-Tyne) had seen the driving of the drift, and was very much interested therein. He would like to have a definition of what the author meant by hand-drilling, so as to avoid confusion between what he might term "hand-boring" with a rotating auger-like drill and "hand-drilling" by percussion. He agreed with what the author said as to the advantage of hand-feeding a machine-drill, but if he was not mistaken, the Cranston drill was hand-rotating as well as hand-feeding. He was a disbeliever in hand-rotation, and in his experience hand-rotating drills stuck more frequently than automatically rotated drills. Usually the men in charge did not rotate the drill uniformly, and they were apt to rotate it so as to get the bit into a soft spot each time. He would like Mr. Bates to give figures as to the relative quantity of explosive used while hand-boring and while machine-drilling. It had been generally claimed that machine-drilling was more expensive as regards consumption of explosives than hand-boring, but the data available were not quite conclusive. He would also ask why the drill-bits were made as large as $2\frac{3}{8}$ inches in diameter, when the cartridge was only $1\frac{3}{8}$ inches in diameter. The $2\frac{3}{8}$ inches bit would probably drill with a slight clearance, so that there would be about $\frac{5}{4}$ inch or so of vacant space in the hole. Was that done purposely, and was anything gained by the arrangement?

Mr. T. E. Forster (Newcastle-upon-Tyne) said that he quite confirmed what Mr. Bates said about hand-drilling in soft stone; he had driven a drift with a Cranston drill, and he came to the same conclusion. He found the same difficulty with regard to the simultaneous firing of shots by electricity, but he obtained better results with low-tension than with high-tension fuzes.

Mr. P. Kirkup (Birtley) asked whether rock-drills had been used for the central holes, and hand-drills for the side-holes or pop-shots.

Mr. C. H. Steavenson (Redheugh) enquired whether electric drills had been tried. Such drills were largely used in Cleveland, where they employed very powerful rotary machines.

Mr. T. W. Benson said that he did not notice any comparison of costs between the time when the drift was going by hand-power and when the Cranston drill was used. He had driven some 900 feet of stone-drift (approaching the 90 fathoms dyke from the opposite side to that on which Mr. Bates worked) using ratchet-drills. He was about to use a machine-drill, and he was curious to find out whether there would be

any difference in the cost, but he hoped to get greater expedition. There seemed to be a general consensus of opinion that in moderately hard rock a machine-drill would not do the work any cheaper than ratchet-drills, which had been very much improved of late years.

Mr. SIDNEY BATES said that hand-drilling was not now practised in Northumberland or Durham. The workmen now used rotating drills. The men had had no trouble with bent drills: they generally commenced with the larger drill so as to drill a hole going to a depth of 8 feet. The workmen had tried electric shot-firing, and had voluntarily discontinued its use. Some of the rock was hard compact siliceous sandstone, which bent the ratchet-drills.

Mr. H. LAWRENCE asked whether they had tried a drill that would drill a hole in steps, so that they made a smaller hole at first and the wider part of the drill cut down the shoulder. In exceedingly hard rocks, he had found that they could drill more quickly by drilling a small hole and enlarging it afterwards to full size.

Mr. R. S. ANDERSON (Newcastle-upon-Tyne) said that he was at the present time driving a drift with a Cranston machine-drill. The cost of compressed-air drills was certainly no less than ordinary hand-drilling in stone of ordinary hardness. He had found stone above the Brockwell seam, at North Elswick collieries, harder than any he had ever seen near that seam before, and the workmen had had great difficulty indeed in working it by hand. It was on that account and also on account of the saving of time that he decided to adopt the Cranston drill. The drift would be about 1,500 feet long, and probably they would have considered more seriously before putting in a machine-drill, had it not been for the fact that there was an oil-engine working a pump at a point near where the drift was to commence. An air-compressor was erected at that point and was driven by the oil-engine, which at other times was used for pumping. By this method, there was a saving of cost of expensive plant at the surface, and a considerable length of pipe, with consequent loss of power in-bye. The drift was commenced at a point, 3,600 feet from the shaft. He presumed that the cost of 18s. 2d. per foot, as stated by Mr. Bates, was for the actual working of the drift, and did not include the removal of the stone. It would be interesting if Mr. Bates could give the cost of running the engine, and of the fuel and stores used in connexion with the plant. The members could only make a comparison of the cost of power-drilling and hand-drilling, when all these items were taken into account.

Mr. SIDNEY BATES, replying to the discussion, said that the hand-drilling referred to in his paper was actually hand-boring, as there were not many hand-drilled holes at the present time. The Cranston drill was hand-rotating, which was certainly a drawback; and he believed that automatically rotated drills worked uniformally and required less attention. The quantity of explosive used when hand-boring was 0·068 lb. per cubic foot; and with machine-drills, 0·12 lb. per cubic foot. The drill-bits were made 2⅜ inches in diameter so as to allow ample margin in reducing the diameter in deep holes, and nothing would have been gained by trying to drill the holes with only a slight clearance. All the holes were drilled with machine-drills after the machine-drills were in use. The electrically-driven drills were only tried at the works of an electrical engineer. The cost was a little higher with machine-drills, but the strata was much harder. Without machine-drills, the rate of progress per week would certainly have been much less and the cost much more. He had had experience with oil-engines and certainly he could not recommend their adoption to drive air-compressors in mines. The costs given in his paper only included the money paid to the workmen for blasting the stone and filling it into tubs. The loss of pressure of the air at the end of the drift was 10 lbs. per square inch.

Mr. A. L. STEAVENSON (Durham) had seen a great deal of drilling with compressed air and with electric drills, and his experience very much agreed with those views which had been expressed. He had not found machine-drilling of much advantage in hard post-stone. Perhaps it was because he did not stick to it long enough, but of all the motors he liked compressed air best, because they got fresh air constantly at the face for the workmen. The use of an oil-engine for driving the air-compressor, referred to by Mr. Anderson, seemed to be a very economical method. He (Mr. Steavenson) had tried simultaneous firing, but the places that they were driving in Cleveland were 10 feet high and 14 feet wide. They often drilled 15 holes in a single place before firing a shot, and he thought that if they could use simultaneous firing it would be economical. He proposed a hearty vote of thanks to Mr. Bates for his interesting paper.

The motion was cordially approved.

DISCUSSION OF DR. JOHN S. HALDANE AND MR. F. G. MEACHEM'S "OBSERVATIONS ON THE RELATION OF UNDERGROUND TEMPERATURE AND SPONTANEOUS FIRES IN THE COAL TO OXIDATION," ETC.*

Dr. P. PHILLIPS BEDSON (Newcastle-upon-Tyne) wrote that he had read with considerable interest the paper by Dr. Haldane and Mr. Meachem, which contained a large amount of valuable information on a subject of great practical interest. After the investigations of Richters and others on this subject one was scarcely prepared to learn that such a preponderating influence in heat production should be given to the iron-pyrites contained in coal, as the trend of these investigations had been rather to dethrone iron-pyrites from its exalted position. The authors' contention as to the part played by iron-pyrites would have been strengthened had they given some idea of the composition of the coal with which they experimented, both before and after oxidation. The increase in weight of carbon compounds on oxidation is not very difficult of explanation, for oxidation does not necessarily mean production of carbon dioxide and water, but may simply be the fixation of oxygen. To take a simple case, the oxidation of acetic aldehyde to acetic acid results in 1 part by weight of acetic aldehyde forming 1·36 parts by weight of acetic acid. It is simply an oxygen addition. That such actions may take place with coal is shown in the analyses and experimental results described by Dr. Carrick Anderson in his paper recently read before The Institution of Mining Engineers.†

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* *Trans. Inst. M.E.*, vol. xvi., pages 457 and 495; and vol. xviii., page 15.
† *Ibid.*, 1898, vol. xvi., page 335.

CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

ANNUAL GENERAL MEETING,
HELD IN THE UNIVERSITY COLLEGE, NOTTINGHAM, AUGUST 26TH, 1899.

MR. W. D. HOLFORD, RETIRING PRESIDENT, IN THE CHAIR.

REPRESENTATIVES ON THE COUNCIL OF THE INSTITUTION OF MINING ENGINEERS, 1899-1900.

The SECRETARY read the list of representatives of the Institution upon the Council of The Institution of Mining Engineers for 1899-1900 as follows :—

Mr. G. J. BINNS.
Mr. G. E. COKE.
Mr. M. DEACON.
Mr. W. D. HOLFORD.
Mr. G. A. LEWIS. (*ex-officio*).
Mr. H. LEWIS.
Mr. M. H. MILLS.

The SECRETARY announced the election of the following gentlemen:—

MEMBERS—
Mr. H. A. ABBOTT.
Mr. C. H. WAYTE.

ASSOCIATE—
Mr. G. H. WILBRAHAM.

STUDENT—
Mr. E. M. BAINBRIDGE.

Mr. G. ELMSLEY COKE (Nottingham) gave notice in behalf of the Council, of alterations of the Rules.

The Annual Report of the Council was read as follows :—

ANNUAL REPORT OF THE COUNCIL, 1898-99.

The following is the usual comparative summary of the number of members and the state of the finances in the three preceding annual statements :—

	Year. 1896-97.	Year. 1897-98.	Year. 1898-99.
Honorary Members ...	14	14	14
Life Members	9	9	9
Members	221	234	228
Associate Members ...	2	4	6
Associates...	70	66	64
Students	37	32	33
Totals	353	359	354

	£ s. d.	£ s. d.	£ s. d.
Cash Receipts	504 8 1	458 3 5	476 2 6
Cash Payments ...	506 6 7	515 8 9	499 6 2
Bank Balance	85 11 3	28 5 11	5 2 3
Invested Fund ...	533 6 8	533 6 8	533 6 8
Totals	£618 17 11	£561 12 7	£538 8 11
Arrears considered recoverable at end of year	1896-97. £51 2 0	1897-98. £72 13 6	1898-99. £66 4 6

Eight new members (including 2 transferred), 2 associate members, 6 associates and 3 students have been elected during the year, making a total of 19, as against 10 last year. The total retirements from all causes are 24 as against 17 last year, namely :—14 members, 8 associates and 2 students. There has been a net loss of 6 members and 2 associates, against a gain of 2 associate members and 1 student, making a total net loss of 5.

Three members have died during the year, namely :—Messrs. W. F. Howard, Secretary, Chesterfield ; John Jackson, Past-President, Chesterfield ; and W. E. Wells, Sheffield.

Compared with 1897-98, the income of 1898-99 was £17 19s. 1d. greater ; and the expenditure was £16 2s. 7d. less.

Of the arrears considered recoverable at the end of 1897-98, namely, £72 13s. 6d., the amount of £35 18s. 6d. has since been paid. The Council, however, desire to draw attention to the large amount of arrears still outstanding, and to impress upon the members that, for the proper and efficient working of the Institution, prompt payment of subscriptions is most necessary.

The Council desire to place upon record their deep sense of the loss which the Institution has sustained through the death of the late Secretary, Mr. W. F. Howard. He had held that position from the

formation of the Institution, and to him has been due much of the success which has attended its working. Mr. G. A. Lewis, of Albert Street, Derby, was appointed his successor, by ballot, at the General Meeting in Burton-on-Trent, on April 8th, 1899.

The Council have had under consideration a suggestion to alter the title of the Institution by omitting the word "Chesterfield." Since the foundation of the Institution, Chesterfield has been gradually becoming less of a centre for its members, and at the present time it is very difficult to obtain a good attendance at a Council or General Meeting held in that town. Nottingham and Derby have been suggested as convenient and suitable headquarters, but the new Council will have an opportunity of taking up these questions.

A proposal was made by the Council during the past year to increase the rate of subscription, owing to the cost of publishing the *Transactions*, which are now of a very valuable and bulky character. This course, however, met with opposition, and the proposition was withdrawn. It is obvious, however, from a perusal of the balance-sheets of the past few years, that financial instability is likely to arise, in view of the contribution now payable to The Institution of Mining Engineers. The greatest safeguard in this direction would be, however, an increase in numbers, and the Council would be pleased if members would exert themselves to obtain new nominations.

The annual meeting of The Institution of Mining Engineers was held in September, 1898, in Birmingham, and other meetings were held in February at Stoke and in May in London.

Local meetings have been held as follows:—Annual Meeting in Chesterfield on August 27th, 1898; in Nottingham on December 3rd, 1898; and at Burton on-Trent on April 8th, 1899. In addition, a joint meeting with the Midland Institute of Mining, Civil and Mechanical Engineers took place in Sheffield on March 24th, 1899.

The complete list of papers published in the *Transactions* of The Institution of Mining Engineers since the Council's last Report includes the following contributions from members of this Institution:—

"An Improved Ambulance-Carriage and Stretcher for Use in Mines." By Mr. H. R. Hewitt.

"Colliery Consumption." By Mr. J. A. Longden.

"Electric Blasting." By Mr. Wm. Maurice.

"The Application of Liquefied Carbonic Acid Gas to Underground Fires.' By Mr. G. Spencer.

ABSTRACT OF ACCOUNTS,

	INCOME.	£ s. d.	£ s. d.
199	Members at £1 11s. 6d.	318 8 6	
2	Members transferred from Associates	3 3 0	
5	Members transferred from Students	7 17 6	
3	Associate Members	4 14 6	
62	Associates and Students	62 0 0	
5	New Members at £2 12s. 6d.	13 2 6	
1	New Member (not paid Entrance Fee)	1 11 6	
2	New Associate Members and Entrance Fees	5 5 0	
6	New Associates and Students	6 0 0	
7	Entrance Fees to Members from Students and Associates	3 13 6	
			420 16 0
1	Member paid in advance	1 11 6	
1	Associate paid in advance	1 0 0	
			2 11 6
	Arrear Subscriptions received		35 18 6
	Midland Railway Company's Debenture Interest ...		15 9 4
	Bank Interest		1 7 2
	Balance brought forward		28 5 11
			£504 8 5

YEAR ENDING JULY 31ST, 1899.

EXPENDITURE.	£ s. d.	£ s. d.
The Institution of Mining Engineers:—		
Calls—1898-99 (Vols. XVI. and XVII.)	280 5 0	
Calls—1897-98 (Vols. XIV. and XV.)	22 16 0	
Transactions supplied on payment of arrears ...	13 0 0	
		316 1 0
Excerpts, Exchanges, etc.	16 4 0	
Reducing Plates...	2 10 0	
		18 14 0
Printing, etc.		33 13 10
Auditors		3 3 0
Reporting Proceedings		7 3 0
Fire Insurance		1 2 6
Postages, Parcels, Telegrams, etc.		10 12 6
Travelling and Incidental Expenses		8 17 0
Fees at Meetings, etc.		0 15 0
Secretary's Salary, Assistance and Use of Office		91 13 4
Joint Meeting at Sheffield—Share of Expenses		3 0 11
Burton Meeting—Room		0 10 6
Removing Furniture		0 6 0
Repairs to Bookcase		0 16 2
Altering Bookcase and Removing Boxes, etc.		2 2 7
Bankers' Commission		0 12 4
Cheque Book		0 2 6
Balance in Secretary's hands	2 14 0	
„ Bank	2 8 3	
		5 2 3
		£504 8 5

August 11th, 1899,

Examined and found correct,

JOHN HALL,
JOHNSON PEARSON, } AUDITORS.

DR. THE TREASURER IN ACCOUNT

		£	s.	d.	£	s.	d.
236	Members, as per List, 1898-99, of whom						
8	are Life Members						
228	Members at £1 11s. 6d.	359	2	0			
	Less 1 paid in advance	1	11	6			
					357	10	6
1	Member paid in advance, 1899-1900				1	11	6
2	Associates paid difference as Members				1	3	0
5	Students paid difference as Members				2	17	6
2	Associates paid Entrance Fees as Members				1	1	0
5	Students paid Entrance Fees as Members				2	12	6
4	Associate Members, as per List				6	6	0
107	Associates and Students, as per List,						
1	Student is a Life Member						
106	Associates and Students at £1	106	0	0			
	Less 1 paid in advance, 1898-99	1	0	0			
					105	0	0
1	Associate paid in advance, 1899-1900				1	0	0
5	New Members and Entrance Fees				13	2	6
1	New Member, Entrance Fee not paid				1	11	6
1	New Member, transferred				1	11	6
2	New Associate Members and Entrance Fees				5	5	0
6	New Associates and Students				6	0	0
15					506	12	6
	Arrears as per last Balance Sheet	72	13	6			
	Add Arrears not in last Balance Sheet	1	11	6			
		74	5	0			
	Deduct Irrecoverable, not included in 1899-1900 ...	53	15	6			
					20	9	6
					£527	2	0

WITH SUBSCRIPTIONS, 1898-99. CR.

		Unpaid.	Paid.
		£ s. d.	£ s. d.
198	Members at £1 11s. 6d.		311 17 0
8	Life Members		
1	Paid in advance		
29	Unpaid	45 13 6	
228			
1	Member paid in advance, 1899-1900		1 11 6
5	Members transferred from Students		2 17 6
5	Members transferred from Students paid Entrance Fees		2 12 6
2	Associates paid extra as Members		1 3 0
2	Associates paid Entrance Fees		1 1 0
3	Associate Members, paid		4 14 6
1	Associate Member, unpaid	1 11 6	
69	Associates and Students, paid		69 0 0
36	Associates and Students, unpaid	36 0 0	
1	Student is a Life Member		
1	Paid in advance		
106			
1	Associate paid in advance, 1899-1900		1 0 0
5	New Members and Entrance Fees		13 2 6
1	New Member not paid Entrance Fees		1 11 6
1	New Member, transferred		1 11 6
2	New Associate Members and Entrance Fees ...		5 5 0
6	New Associates and Students		6 0 0
15		£83 5 0	423 7 6
	Arrears as per last Balance Sheet	38 6 6	35 18 6
		£121 11 6	
	Deduct as Irrecoverable	53 15 6	
			67 16 0
			£527 2 0

August 11th, 1899.—Examined and found correct,

JOHN HALL,
JOHNSON PEARSON, } AUDITORS.

The CHAIRMAN (Mr. W. D. Holford) moved that the Report of the Council, together with the abstract of the audited accounts for the past year, be adopted.

Mr. EDWARD LINDLEY (Eastwood) seconded the motion, which was adopted.

ELECTION OF OFFICERS—1899-1900.

The SCRUTINEERS, who received a vote of thanks for their services, reported the result of the ballot as follows :—

PRESIDENT.

Mr. MAURICE DEACON.

VICE-PRESIDENTS.

Mr. W. H. HEPPLEWHITE.	Mr. J. H. W. LAVERICK.
Mr. C. R. HEWITT.	Mr. C. SEBASTIAN SMITH.
Mr. J. P. HOUFTON.	Mr. H. WALTERS.

COUNCILLORS.

Mr. G. H. ASHWIN.	Mr. C. LATHAM.
Mr. G. J. BINNS.	Mr. E. LINDLEY.
Mr. P. M. CHESTER.	Mr. C. H. OAKES.
Mr. A. S. DOUGLAS.	Mr. G. SPENCER.
Mr. H. FISHER.	Mr. J. T. TODD.
Mr. W. B. M. JACKSON.	Mr. W. WILDE.

VICE-PRESIDENTS OF PREVIOUS YEAR (*ex-officio*).

Mr. G. E. COKE.	Mr. H. R. HEWITT.

Mr. W. D. HOLFORD said that his year of office was now closed, but before he left the chair he would like to express his indebtedness to the members of the Council and the Secretary for the assistance which they had rendered him.

Mr. W. WILDE (Sheffield) moved a vote of thanks to Mr. W. D. Holford for the care and attention that he had given to his duties during the past year. Mr. Holford had, he knew, devoted a considerable amount of time to the affairs of the Institution—necessitated, in a very great measure, by the death of their late Secretary, Mr. W. F. Howard.

Mr. M. DEACON (Sheepbridge) seconded the motion, which was cordially and unanimously adopted.

The PRESIDENT (Mr. Maurice Deacon) then took the chair and delivered the following address :—

PRESIDENTIAL ADDRESS: THE EDUCATIONAL AND SOCIAL CONDITION OF COLLIERY-OFFICIALS AND WORKMEN.

By MAURICE DEACON.

My first duty is to thank the members for the honour they have conferred upon me by electing me their President for the ensuing year. With the assistance of the Council and the members of the Institution, I hope that I may be successful in filling the office with some measure of success.

In seeking for a subject upon which to address you to-day, I have experienced considerable difficulty in finding one which has not already been exhaustively treated by past Presidents.

Any subject having for its principal objects the greater safety and the improved condition of the employed, both of which must reflect indirectly upon the interests of the employer, will doubtless be studied with interest by the members, and although such a subject can hardly be considered as coming within the category of engineering in its strictest sense, it may nevertheless be treated as forming an important part of the work of the mining-engineer and of the colliery-manager.

The education and training of the mining-student has already formed the subject of at least one address by Presidents of this or affiliated Institutions, and I now propose to prosecute this important subject still further in the consideration of the educational and social condition of colliery-officials and workmen. By the term "colliery-officials," I mean those officials who occupy a lower position than that of the certificated manager.

It will not, I presume, be denied by any member of this or any other scientific Institution that the culture of the human intellect, whether in the man who earns his livelihood by the effort of his brains, or in the man who does so by the exertion of his physical powers, can only result in producing a more useful member of society both in the working and social spheres of life; neither will it be denied that both in the colliery-official and the miner great scope is presented in this direction, and that where the good influence of the colliery-manager has been brought to bear, satisfactory results have ensued. It cannot, of course, be expected

that any very great impression can be made upon the masses by individual effort in a short space of time, but it may be safely said that the foundation may be laid by this generation of colliery-managers, to be carried on and completed by those who follow us ; and the fact that the work must necessarily be long and sometimes discouraging should not deter them from doing their share in this good and important work. It is with the object of endeavouring to encourage them, especially the younger ones, to exercise their abilities and energies in this direction that I have ventured to introduce the subject to your notice to-day.

The colliery-official is generally a fairly intelligent man, who performs his duties as far as he is able in a creditable manner, but his education and training are often so far deficient as to deprive him of the power of rendering to his employer, and to his fellow-workmen, the full value of his latent intelligence. This points to the strong necessity of a better system of educational and disciplinary training than had generally obtained in the past.

Technical classes are in many places established under the Science and Art Department and County Council educational schemes, which may be utilized by everybody who has the desire to improve himself ; but many of these classes are located at considerable distances away from our colliery-villages, and are sometimes difficult to reach. This difficulty frequently results in both officials and workmen preferring to stay at home rather than incur the fatigue and expenditure of time involved in attending such classes ; so that it appears to be necessary to bring the centres of technical education nearer to the collieries if any material advantage is to be derived from them.

There is no reason why every colliery-village in the kingdom should not have such classes established in its own schools or public halls, so that they might be reached in reasonable time and without the necessity of long walks or railway journeys. Even then, the result cannot be expected to be successful without the influence and personal interest of one or more of the most influential residents in the neighbourhood, and no one can be better fitted for this duty than the colliery-manager, from the fact that he is more in touch with his men and should have greater influence over them than anyone less intimately associated with them. In those cases where it is impossible to establish such classes from the difficulty of obtaining teachers, the colliery-manager and his assistants may with advantage devote a portion of their spare time to giving lectures upon interesting scientific subjects, which if illustrated with

experiments and diagrams may be made very instructive and attractive. In every colliery-village there are a considerable number of intelligent youths who only require to be directed in the way of obtaining knowledge to be quite ready to embrace opportunities of improving themselves and becoming fitted for occupying responsible positions.

The ample room for improvement in the technical training of underground officials and enginewrights is only too frequently experienced by the colliery-manager, to whom considerable trouble is often caused by the inability of an enginewright to make an intelligible and accurate drawing or to correctly set a valve, or of an underground official to give him an accurate idea of the cost of getting coal in his district, or to use that foresight in the laying out of the workings, and the judicious expenditure of money where it is required (and not where it is unnecessary), which is so indispensable to economical working. Such classes as those to which I have referred should give the underground official tuition in the theory of ventilation, different methods of timbering, the chemistry of the gases met with in mines, shot-firing, underground fires, etc., as well as interesting information regarding the engineering of collieries. The study of these important subjects, which in the absence of better knowledge the ordinary official frequently manipulates by rule of thumb, not only renders him a more useful servant, but adds to the interest which he takes in his own work, so causing his labour to become a pleasure rather than a toil.

The study of mechanics, hydrostatics, steam, mechanical drawing and machine-construction by the enginewright renders him of greater value to his employer, greatly increases the interest which he takes in his own work, and opens up to him a road to success in a much higher sphere than he could otherwise have expected to attain.

Ambulance classes are established in most colliery centres and to a moderate extent have been successful. It frequently happens, however, that the lectures are irregularly attended, and as soon as the examination is over, no more attention is paid to the subject. In order that permanently good results may be obtained, the classes should be held every year, and those who have succeeded in getting the first certificate, should be urged to regularly continue to attend the subsequent lectures until they have obtained their medallion ; and even then occasional meetings for practice in bandaging, stretcher work, etc., should be held in order to prevent the gradual loss of the knowledge which had previously been gained. This requires the constant interest and attention of the colliery-manager, without which the classes will flag, and the interest

taken by the men will decrease. No winter should be allowed to pass without a class being held, and no colliery-manager should be satisfied until he had at least one competent ambulance-man in each stall. Ambulance-drill may accompany the classes with great advantage: the disciplinary effect being good, and producing its influence upon the men in their daily work.

In endeavouring to establish a system of training such as that to which I have referred, the colliery-manager should, as far as possible, make himself acquainted with the character of the most promising boys in the village schools, and by encouraging them when they have left school to continue their education by attending evening continuation-schools, lay the foundation for future technical study. In this way he will have under his eye a number of youths, who, as they develop into full-grown men and obtain the necessary experience in mining or engineering, will form an useful source of selection for deputies and other officials.

Personal knowledge of the boys may be best obtained by organizing and taking an active interest in cricket and football-clubs, Sunday-schools and choirs, and in the establishment of ambulance-classes and boys' brigades. With such organization, careful superintendence, and encouragement as I have suggested, a more intelligent race of officials may be created, resulting in greater safety to the persons employed in mines as well as in the more economical production of coal in the future.

Although I have treated the subject as applying to colliery-officials more particularly, there is no reason why the ordinary intelligent workman should not avail himself of the advantages so offered, and, indeed, it is most desirable that he should be encouraged to do so in order that he may second the efforts of managers and officials to increase the safety and economy of our mines.

The social condition of the miner is a subject of great interest to the colliery-owner, and it is by no means of small importance in the economical working of collieries. Every colliery-owner directly or through his manager should make it part of the business of carrying on his collieries to take an interest in the social welfare of his men, and so far as possible, to establish sources of instruction and amusement amongst them. Perhaps the most important step in this direction is the provision of comfortable, sanitary and neat dwellings, than which there is perhaps no surer way of elevating the tastes and brightening the lives of the workmen, and, perhaps, no better counter-attraction to

the public-house. The provision of gardens immediately connected with the houses and the organization of exhibitions and prizes for the best productions, will encourage the workman to make the best of his home.

In the case of existing collieries, which are not provided with such houses, it will of course be impracticable to make any material change, but the provision of a few semi-detached cottages with gardens for officials and workmen who prefer to spend their money in home comforts rather than the public-house and railway-excursions, will be found of great advantage in creating a class of self-respecting and industrious men.

In the case of new collieries, where no provision for the housing of workmen exists, the question of comfortable dwellings for the men is one of the most important to be solved by the colliery-owner, and whilst he naturally looks for a reasonable return upon his outlay, he must remember that this may be obtained more readily by the services of steady and respectable men than by high rents. An extension of the advantages of comfortable houses may be found in giving the workman an opportunity of purchasing his house on favourable terms by weekly payments. I am aware that this has been attempted and has more or less failed in the past; but I am nevertheless convinced that it is a desirable policy to pursue, and if the terms are made sufficiently easy, I see no reason why it should not be successfully carried out, to a limited extent.

Football and cricket-clubs are so universal as to be almost unworthy of mention, were it not for my desire to call attention to the desirability of the influence and control of the colliery-manager being exercised in the men's amusements as well as in their educational pursuits.

The provision of workmen's institutes is an excellent means of counteracting the evil influence and abuse of the public-house and of exercising personal influence upon those who frequent them; but the necessity for stringent rules and their effectual observation again calls for the control of the colliery-manager, the want of whose frequent presence and constant watchfulness, may convert what was intended as a blessing into a curse. It may be argued that an easy method of getting over the difficulty of the undue use of intoxicants at institutes is to prohibit their sale. I have had some experience of workmen's institutes on teetotal principles, and I have found that whilst it has doubtless advantages for those who are not regular consumers of alcohol, and that it offers facilities for keeping youths away from the public-house, yet it

does not form sufficient attraction for the majority of a mining population, who for the most part choose to take their glass of beer, and who naturally gravitate to the public-house to obtain it, frequently meeting with temptations to take more than is sufficient for their wants or desirable for their pockets. I am, therefore, inclined to think that the supply of beer and spirits in moderate quantities at such institutes is likely to produce better results than an attempt to convert the miner into a teetotaller, or to send him to the public-house to satisfy his natural and proper desire to have his glass of beer. Such institutes may contain reading-rooms, lecture-rooms, billiard-rooms and card-rooms, and the addition of a gymnasium, bowling-green, skittle-alley and swimming-bath, will add materially to the attractions.

Whilst the colliery-owner may be sufficiently liberal to provide such an institute free of cost, I am strongly impressed with the desirability of letting the men and officials take their share of the responsibility both of providing the funds, and in the management.

This may be best accomplished by the formation of a limited company in which the owner, officials and workmen should take a pecuniary interest, each having a share in the management somewhat proportionate to their holdings. A wellmanaged institute with proper restrictions placed upon the amount of intoxicants to be sold to any single person, and the strict prohibition of gambling and bad language, can have only one effect, and that is the improvement and elevation of those who frequent it.

For the amusement and instruction of boys, a separate building should be provided, so as to have no connexion with the men's institute. This may be provided with reading-room, lecture-room and gymnasium. A careful selection of books and papers, so as to form a small library in connexion with the reading-room, will form a source of additional interest to the members. Occasional lectures on scientific and other instructive subjects, illustrated by lantern-views, will be appreciated and useful. A boys' brigade should be established in connexion with the institute, by which discipline may be taught. The cricket, football and other clubs should be managed by a committee of the institute, consisting partly of boys and partly of officials.

The encouragement of music is another civilizing element which will go far to elevate the tastes of the men and their families. There is no colliery-village which does not contain more or less musical talent, and in colliery-villages especially, I have frequently met with a considerable amount of musical ability and appreciation of music. Few villages are

without some person, either in the schoolmaster or the organist, who is capable of organizing a musical society, either choral or instrumental; and if the colliery-manager himself happens to be capable of taking such work in hand and devotes his personal efforts to the establishment of such a society, successful results are so much the more likely to accrue.

The identification of the colliery-manager with the friendly societies in his neighbourhood, and his attendance at their meetings and festivities is another useful direction in which he may exercise his personal influence to the advantage of both employer and employed, and he will not feel disappointed at having spent a few hours in this way, or the inconvenience which it may have caused him, to spare the time, or perhaps to deprive himself of some other pleasure.

I have briefly referred to a few ways in which the colliery manager may exercise a useful influence over the social condition of the people with whom he is in daily contact, and at the same time perform useful service to his employer. It must be borne in mind, however, that the carrying out of such a programme as I have suggested entails the sacrifice of a good deal of time, and the results are not always immediately apparent. The successful issue of the manager's efforts depends very largely upon his power of organization and of causing others to interest themselves in the work, the absence of selfish interests, the exercise of patience and tact, and the firm control of those who may be inclined to introduce disturbing influences.

It may be said by some colliery-managers that they have not time to perform social duties, and by others that there is nothing in the results to justify them in doing so. To these I would suggest that: (1) The person who has the least time to spare is generally the one who finds time to do the most. (2) The colliery-manager is essentially the proper person to exercise a good influence over his men and their families, and that though the results may be slow, they will be expended in the development of a respectable and respectful class which will benefit their employer as well as themselves by their greater industry and tractability; and (3) the accomplishment of only a small part of what I have foreshadowed will be an ample reward for the time and energy expended.

Having dealt with such methods of improving the social condition of our mining workmen as suggest themselves to me and as come within the law, I venture to make one further suggestion by which the welfare of a considerable proportion of our miners might be very far advanced,

and this suggestion is, the amendment of the Truck Act in such a manner that the workman should be permitted to take part payment of his wages in orders for food and clothing upon some shop or shops to be agreed upon between the employer and employed, instead of being compelled to wait for the whole of his wages until the pay day, one half of which frequently does not reach his wife and children. Such an alteration in the law might be made in a manner which would admit of the workman being protected against the compulsory purchase of inferior articles and exorbitant prices being charged for goods so obtained, which constituted the grievances which the Truck Acts were designed to redress. Such a reversion to freedom of contract in this "free country" would go far to reduce the present cause of excessive drinking, and would counteract the evil of over-legislation, by which an attempt to place restrictions upon the free action of the subject with the good intent of abolishing one evil, frequently gives rise to another evil of greater magnitude.

In conclusion, I wish to express the hope that during my year of office the younger members of the Institution may be induced to launch out in the writing of papers. They need not be afraid of undue or unfair criticism, and they will find that their efforts will be received in a friendly and encouraging spirit by the older members. By doing so they will gain experience and confidence in stating their opinions before others, and will to some extent benefit by becoming accustomed to speaking in public. They will in addition have the satisfaction of knowing that they will have done something towards enlightening their fellow-members, and in performing a duty which attaches to every member, namely, to advance the interests of the Institution. Long and elaborate papers are not necessary, nor are they desirable. Short practical papers on actual experiences are of far more value than lengthy theoretical dissertations, whilst they are much less trouble to write, and generally induce better discussions.

With regard to the financial position of the Institution, funds are required, and there is a long list of arrears of subscriptions. May I ask and hope that during my year of office all arrears will be paid up and the Institution be placed upon a permanently sound financial basis without the necessity of increasing the subscriptions?

Mr. W. D. Holford proposed a vote of thanks to Mr. Deacon, who, he said, had touched upon many matters which ultimately would be carried out.

Mr. J. A. LONGDEN (Stanton-by-Dale), in seconding the vote of thanks, said that sometimes papers were read containing suggestions by people who had no idea how great were the difficulties raised by their suggestions, but Mr. Deacon had spoken from experience. He (Mr. Longden) found that while Institutes were in debt they got on, but when they were free from debt they began to go back. Mr. Emerson Bainbridge took great interest in the Young Men's Christian Association in Sheffield and interested himself in the erection of a splendid building, but he believed that they had not been so successful in their handsome premises as they were when in a struggling condition. He had great pleasure in seconding the vote of thanks to Mr. Deacon for his interesting address.

The resolution was cordially adopted.

DISCUSSION OF MR. J. A. LONGDEN'S PAPER ON "COLLIERY CONSUMPTION."*

Mr. A. H. STOKES said that, in the paper, references were made to so many tons, or to so much fuel, but they had no analyses of the fuel. If a dirty tub of coal came to the pit-bank and was condemned as unfit for the screens, or for sale, instructions were generally given to "push it into the fire-hole." Now such fuel affected the colliery-consumption; and if its value be taken they would find it rather expensive, especially in the matter of labour of firing. In all papers upon colliery-consumption it was requisite to know not merely the quantity, but the quality of the material used.

Mr. GEORGE LEWIS (Derby) expressed his concurrence in the remarks of Mr. Stokes. As a rule the best quality of fuel was not placed under the boilers. The paper would have been of greater service if it had recorded the actual value of the fuel, supposing that it had been put into the market.

Mr. A. S. DOUGLAS (Hucknall Torkard) agreed that they ought to know not merely how much, but what description of fuel was used under the boilers. In the Leen Valley, the colliery-consumption was less than 1 per cent. for every 300 feet in depth. A friend said that he preferred cylindrical to Lancashire boilers, because it was desirable to burn all waste under the boilers. The cylindrical boiler was a "gob-hole" where

* *Trans. Inst. M.E.*, vol. xvi., page 366; and vol. xvii., page 253.

they could dispose of all unsaleable fuel in a better way than tipping it over the dirt-hill, where it created a nuisance. Looked at in that light, it seemed to him that the boiler which consumed the greatest amount of waste fuel was under certain conditions the best boiler.

Mr. SEBASTIAN SMITH said that he had endeavoured to economize by using a forced draught, enabling him to keep up a pressure of steam of 80 pounds per square inch with nothing but fine dust-fuel, and he had never met with any difficulty in doing that. He had found difficulties in applying the system to cylindrical boilers, but he had no doubt of the economy of forced draught when used with Lancashire boilers. He should be glad if Mr. Longden would read an addendum to his paper, and tell him how to consume the smoke which came from his boilers, and to get rid of the sulphurous acid which was so detrimental to the agricultural interest.

The PRESIDENT (Mr. M. Deacon) said that one point which struck him was that the rough-and-ready way of taking out percentages was of little value for general comparative purposes. For week-to-week comparison at the same colliery—presuming that the same fuel was used—it was a useful method of comparing variations; but to those who had charge of more than one colliery it did not afford a useful means of comparing one colliery with another. A preferable plan was to compare the consumption of fuel in pounds per indicated horsepower for each engine; this shewed the weak points requiring improvement. The colliery-consumption at adjacent collieries—where the quality of coal consumed was precisely the same—at one pit was 7 per cent. and at the other 0·77 per cent. The latter consumption was extremely low, but only one boiler was fired with fuel, and all the others with waste gases from coke-ovens. The winding-engine, however, was most economical; it was fitted with Corliss valves, and gave perfect results at a steam-pressure of 120 pounds per square inch. Mr. Longden advocated the use of steam at a pressure of 120 pounds per square inch, and he had generally been of the same impression; but a celebrated engine-builder, the other day, assured him that practical experience proved that for a compound condensing engine, the most economical boiler-pressure was 80 pounds per square inch. It was something new to him, and he was going to try to find out whether this statement was right or wrong.

Mr. J. A. LONGDEN suggested that Mr. Douglas should try a refuse-destructor, about which one read so much in the reports of town-council meetings. Several town-refuse destructors were producing enough heat to

generate steam for electric-lighting stations, and engineers ought to be able to burn inferior coal in such a way as to generate steam also. The eight collieries named in his paper used similar fuel under their boilers, namely, refuse coal which was unsaleable in the market, and in each case the value was 1s. per ton at the pit without any variation for a rising or falling market.

The best smoke-consumer and the only perfect one in use, was to fire the boiler by producer-gas, but this system was costly, and when the gas-producers were fired with refuse coal they did not last long. The gas-producers, largely used at Messrs. Brunner, Mond & Co.'s works, consumed hard coal-slack, which did not clinker, and the results were very satisfactory, but soft coals were not suitable.

The low colliery-consumption referred to by Mr. Deacon was the result of using coke-oven gases. In his (Mr. Longden's) experience, coke-oven gases were nearly all given off at night, when steam was not required for winding purposes, and the cold air drawn into the flues during charging, and the consequent reduction of temperature during the time that the ovens were drawn and reloaded with coal, caused the value of coke-oven gases for firing boilers of winding-engines to be very small. The statement that an 80 pounds pressure was the most economical for use in compound condensing engines was astounding, in face of the recent decision of the Admiralty to go up to 300 pounds. There might be a limit with Lancashire boilers, but engineers were not confined to Lancashire boilers in all their operations. He had recently erected a Hornsby boiler at Silverhill colliery, owing to the confined space available, and so far it had answered his expectation. Such boilers, however, were objectionable where the water was bad.

DISCUSSION OF MR. W. W. CLAYTON'S PAPER ON "THE USE AND ABUSE OF COLLIERY LOCOMOTIVES."*

Mr. G. S. Bragge (Granville Colliery) said that he had found a reduction of the number of tubes in the boiler to be a decided advantage. Could Mr. Clayton state how far the number of tubes could be reduced without impairing the steam-generation? The greater percentage of steam was generated in the fire-box, and the tubes only performed a secondary part in the formation of steam. Certainly if scale was deposited in the boiler, it was desirable to use a smaller number of tubes, so as to afford facilities for removing the scale. He also agreed with

* *Trans. Inst. M.E.*, vol. xvii., page 212; and vol. xviii., page 72.

Mr. Clayton that water containing magnesia was fatal to colliery-locomotives; and with such water it was desirable to erect a softening plant and purify the water.

Mr. W. SPENCER said that water should be purified before it went into a boiler. He had replaced the small tubes in a locomotive with fewer tubes of larger diameter, and steam was much more readily produced.

Mr. J. BAGNOLD SMITH believed that water containing magnesia was troublesome to use, but he thought that it depended on the amount of the double salts of lime and magnesia. He had always understood that water containing sulphate of lime was most unsuitable for use in locomotive boilers.

Mr. G. S. BRAGGE stated that 11 lbs. of ordinary lime (costing, say, 1¼d.) and 8 lbs. of carbonate of soda (costing, say, 2d.) was used in softening 4,000 gallons of water, or, say, about 1d. per 1,000 gallons treated. The cost of softening water would vary according to the quality of the water used.

Mr. SEBASTIAN SMITH said that he had just erected a water-softening plant, but it had only been in use for a comparatively short period; up to now he found that the hardness was being reduced from 29 to 5½ degrees. When using hard water, the shell of the locomotive became so quickly worn out that instead of standing a renewal of the fire-box two or three times, it was seldom found worth while to put a new fire-box into the shell.

The PRESIDENT (Mr. M. Deacon) said that in a water-softening plant which he had erected, the hardness of the water was reduced from 24 to 6 or 7 degrees, at a cost of less than ¾d. per 1,000 gallons. The water now, instead of forming a thick incrustation, merely formed a slight scale, about $\frac{1}{32}$ inch thick in a month.

DISCUSSION OF MR. WM. MAURICE'S PAPER ON "ELECTRIC BLASTING."*

Mr. J. A. LONGDEN said that he had a circular sent to him offering detonators at £1 10s. per 1,000. He found that he was paying £5 5s., and he suggested that there was room for economy. He was told by

* *Trans. Inst. M.E.*, vol. xiv., pages 142 and 445; vol. xv., page 189; and vol. xvi., page 128.

Mr. Piggford that cheap detonators had been tried, that they were useless, and that to ensure successful results it was necessary to pay the higher price. In their case, the detonators were all carefully tested before they were used in the mine, and they had no miss-shots.

Mr. A. H. STOKES strongly advised mining engineers not to purchase detonators on account of their cheapness, as a few shillings saved in the purchase of 1,000 detonators was nothing compared to the loss in a stall if they had a missed-shot, and had to send the workmen out for the day. At one colliery in the district they had something like, he believed, 27 missed-shots per 1,000; and on giving the order for detonators to another firm the miss-fires were reduced to 1½ per 1,000 shots. At another mine 6,000 shots were fired without a miss-fire. The use of electricity in blasting required that the shots should be fired by an official, thus ensuring both the safety of the workmen and a better quality of coal; for when a workman fired shots indiscriminately, and had no responsibility except that of getting coal, he often failed to plant and charge the same judiciously, or was hasty in firing the shot, whereas an intelligent and experienced official would see that the shot-hole was placed in the best position, and be careful not to overcharge the hole, thus securing better results with the least expenditure of explosive and an official inspection before the shot was fired.

The PRESIDENT (Mr. M. Deacon) thought that shot-firing by an intelligent official would be better done than by an average workman, but it seemed to him that there were very great difficulties connected with it. For instance, they made a contract with a collier to get coal at a certain price per ton, and if he were to be subjected to the dictation of an official as to where he should place the shots, and how much explosive should be used, it would conduce to serious difficulties. But if the collier drilled his own shot-hole, and placed his explosive in it, and then the shot was fired by an official, he did not see that any serious objection could be raised.

The further discussion was adjourned.

MEMOIRS OF DECEASED MEMBERS.

Mr. JOHN PETER JACKSON was the fifth son of Sir William Jackson, Bart., of Birkenhead, who for some years represented North-east Derbyshire in Parliament. He was born in 1843, and was educated at Harrow, leaving there in 1860 in order to be articled to Messrs. Woodhouse & Jeffcock, of Derby, who at that time were perhaps the best-known firm of mining engineers in the country. During his term of apprenticeship, Messrs. Thomas Carrington, G. Fowler, A. Lupton, W. Pilkington, and others who have since become well known in the mining world, were fellow-pupils, and with all of them he maintained a lifelong friendship. Mr. Jackson had much experience in colliery-work while with Messrs. Woodhouse & Jeffcock, both in sinking and opening out new collieries in Derbyshire, Nottinghamshire and Leicestershire; and for some time towards the end of his apprenticeship he lived at Moira colliery, and assisted Mr. Woodhouse in the management.

On leaving Messrs. Woodhouse & Jeffcock, he went to the Clay Cross Company, in which his father was largely interested, and took up the management of the collieries under the late Mr. Charles Binns, who was at that time the general manager; and under his superintendence several pits were sunk and the output much increased. He continued to act in this capacity until 1881, when, on the retirement of Mr. C. Binns, he assumed the general management of the colliery and ironworks, and he continued to hold this position until his death, although from 1892 failing health necessitated his taking a less active part in the management. Mr. Jackson was also chairman of the Netherseal Colliery Company, Burton-on-Trent, and a director of the Bettisfield Colliery Company, North Wales.

In 1882, the serious explosion at the Parkhouse Pit, involving the loss of 45 lives, threw upon Mr. Jackson much of the responsibility of the work of rescue and recovery, in which he was assisted by the late Mr. Evans and Mr. A. H. Stokes, H.M. inspectors of mines, as well as by many of the neighbouring mining engineers. The explosion was a great blow to Mr. Jackson, and he always lamented the loss of life which it caused.

Mr. Jackson was one of the founders of the Chesterfield and Midland Counties Institution of Engineers, and throughout his life took great interest in the welfare of the Institute. He was a regular attendant at the general meetings, took an active part in the discussions,

and in 1875 contributed an interesting paper on underground haulage. He was president in 1890, the year of the formation of The Institution of Mining Engineers.

Mr. Jackson was an examiner under the Board for Examinations for the Mining District of Derbyshire, Nottinghamshire, Leicestershire and Warwickshire from 1873 to 1883, and a member of the Board from 1879 to the date of his death; he was also Chairman of the Derbyshire, Nottinghamshire and Leicestershire Coal Owners' Association from 1895 to 1897, and a member of the committee which met Lord Rosebery and settled the coal-strike of 1893.

Mr. Jackson was always held in high esteem by the Clay Cross workmen, who have been known on more than one occasion to refer to him as a model employer. In addition to his professional duties, Mr. Jackson was interested in local and county matters; he was chairman of the Chesterfield Rural District Council from 1896 to the time of his death in February, 1899, he also represented the Clay Cross district on the first Derbyshire county council, and was subsequently made a county alderman. On the formation of the Technical Instruction Committee, Mr. Jackson was appointed chairman, and did much to promote the teaching of mining engineering and other allied subjects in the manufacturing districts of the county, and there are probably few counties in which these subjects are more widely taught than in Derbyshire.

At Clay Cross and Ashover (in which parish Stubben Edge, his home for 25 years, is situated) he was known and respected, and probably few men in the district were better known and more esteemed. He had the faculty of obtaining the friendship and esteem of all who knew him, and when he passed away, after a long and painful illness, it was truly said of him that he had many friends but not one enemy.

Mr. WILLIAM FREDERICK HOWARD, son of Crisp Howard, R.N., was born at Wickham Market, Suffolk, in September, 1829. His business career was commenced with Mr. Clout, civil engineer, of Great George Street, Westminster, to whom he was articled. He subsequently accepted an engagement with Mr. W. B. Beaumont at Bretton Park, Yorkshire, where he studied and took up the subject of mining engineering. Some years afterwards he was appointed to a responsible position at the Staveley Works under Mr. Richard Barrow, who founded the works and collieries which have since grown into the large and prosperous undertaking now owned by The Staveley Coal and Iron Company, Limited.

Shortly after the formation of the limited company, Mr. Howard commenced business on his own account in Chesterfield, and was one of the original promoters of what was then known as the Chesterfield and Derbyshire Institution of Mining, Civil and Mechanical Engineers, and now known as the Chesterfield and Midland Counties' Institution of Engineers. He was appointed Secretary of the Institution in 1871, a position which he continued to hold until his death, a period of nearly 28 years.

The Institution, with Lord Edward Cavendish as its President, took the first practical steps towards providing in Chesterfield a suitable memorial to George Stephenson, whose last days were spent at Tapton, a short distance outside the town, and whose remains repose in Holy Trinity Church. The need of a place where the various educational institutions of the town could hold their meetings was greatly felt; and it was decided that the Stephenson Memorial Hall should be built on such a scale as to provide a public hall, with accommodation for Science and Art Classes, the Institute of Engineers and other societies, and a free library. Mr. Howard was appointed Secretary of the Committee, which after encountering many serious difficulties had the satisfaction of seeing their work accomplished, and the building was opened in 1879.

Mr. Howard was for 25 years a member of the Institution of Civil Engineers, and for a longer period of the North of England Institute of Mining and Mechanical Engineers, to which he contributed three valuable papers on underground surveying, etc. He also did a considerable amount of excellent work in connection with the Statistical Society of Great Britain.

Mr. Howard took a deep interest in educational matters generally, he was exceedingly courteous and affable in demeanour, though naturally of a somewhat retiring nature, and enjoyed the respect and esteem of all who were brought into contact with him.

His death took place at his residence, West Park, Chesterfield, on February 19th, 1899, in his 70th year.

MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.

GENERAL MEETING.

HELD AT THE BULL HOTEL, WAKEFIELD, NOVEMBER 25TH, 1899.

MR. W. H. CHAMBERS, PRESIDENT, IN THE CHAIR.

The minutes of the previous General Meeting were read and confirmed.

The following gentlemen were elected, having been previously nominated :—

MEMBERS—

Mr. GEO. WM. BOUSFIELD, Electrical Engineer, Altofts, Normanton.
Mr. STEPHEN BURRIDGE, Mechanical Engineer, 25, Change Alley, Sheffield.
Mr. DAVID CURRIE, Mining Engineer, 3, Great Winchester Street, London, E.C.
Mr. JOHN ARTHUR DAYSON, Colliery Engineer, Housley Villas, Chapeltown, Sheffield.
Mr. HERBERT ANTHONY EVANS, Mining Engineer, 19, Windsor Esplanade Cardiff.
Mr. GEO. P. KELL, Mining Engineer, Warren House, Barnsley.
Mr. ROBERT ROBSON, Colliery Manager, North Road, Ravensthorpe.

Mr. W. H. CHAMBERS (Denaby and Cadeby Main Collieries) read the following "Notes on Gob-fires":—

NOTES ON GOB-FIRES.

By W. H. CHAMBERS.

In deference to numerous requests the writer ventures to describe to the members some of his experiences of gob-fires, which are undoubtedly one of the most dreaded contingencies of the unavoidably perilous operation of coal-mining. A desirable object will be attained if the reading of this paper promotes consideration and discussion of the subject, and more especially if members, who have had to contend with exceptional difficulties of this character, will co-operate with the author in carrying out his object. Perhaps the greatest of all benefits to be derived from associations of this character is to render assistance and support to mining-engineers who may be so unfortunate as to be placed in perplexing situations where they will be glad to rely in some measure on the expressions of opinion and experience of others who have been similarly circumstanced.

The exhaustion of the more accessible portions of the coal-seams renders it necessary to follow them to greater depths, and it is certain that continually enhanced liability to gob-fires will be incurred in a corresponding ratio, and it is an incident that will tax the ingenuity of the mining-engineer in devising means of prevention as well as of cure.

(1) One of the writer's earliest experiences of gob-fires was upwards of 30 years ago, when he had an opportunity of seeing an attempt to extinguish a fire which had broken out in the workings of a colliery near Rotherham, belonging to Earl Fitzwilliam. In this case, carbon dioxide was generated by passing atmospheric air through a coke-and-lime fire, and it was forced in pipes down the shaft, which was otherwise sealed. This operation went on constantly for some weeks, and then the shafts were completely closed, and kept so for many months. When it was considered that a sufficient time had elapsed, the shafts were opened and ventilation restored, but by the time the atmosphere in the workings was such as to allow of an inspection being made, it was found that the fire was burning as fiercely as ever. The writer, then, arrived at the conclusion that the experiment failed because there

was no alteration (after the restoration of ventilation) in the conditions which enabled combustion to proceed, that the carbon dioxide merely suspended the burning, the fire simply becoming latent when deprived of oxygen.

This system would be effective under ordinary conditions in extinguishing fire, as the heat generated by the previous combustion would be abstracted from the incandescent material and be otherwise diffused, but in a mine, covered by so vast a thickness of strata of low conductivity, the temperature would be maintained for a very long period of time. It follows, therefore, that no method will be applicable to the extinction of underground fires unless (1) means are provided for cooling the hot material, by the application of substances which will absorb the heat until the temperature is lowered to such a degree that combustion entirely ceases in a natural atmosphere, or (2) by the removal of the combustible material from the influence of the heat.

(2) *Denaby Main Colliery.*—Another instance, in the opinion of the writer, confirming the conclusion to which reference had been made, was the case of a gob-fire, which eventually became of such magnitude as to cause the abandonment of the whole of the then existing workings at Denaby Main colliery in 1879. Futile attempts had been made to confine a fire which was discovered in an old waste in the longwall workings, by blocking up the roads communicating with it. For a few weeks, no indication of the spreading of the fire was perceived, but it then made itself evident beyond the stoppings, which were intended to limit it. It was then covering so large an area that it became unsafe for the working of coal to be continued, and the whole of the workings were sealed by means of stoppings built in the two main roads about 450 feet from the shaft-bottom (Fig. 1, Plate VI.). None of the coal to the dip-side of the shafts had up to that time been opened out, and the men were transferred thither as quickly as room could be made for them. A substantial pillar of coal was left, to isolate the new from the old workings.

In 1882, a drift, *C D* (Fig. 1, Plate VI.), was commenced, in order to obtain access to that portion of the coal which lay to the rise of the shaft, the working of which had been suspended. The road was driven in the bind constituting the roof of the seam, and about 10 feet above the coal. When the drift reached the point, *E*, above the site of a few stables, fire was discovered on the left-hand side in the heading. The whole of the floor of the drift was then excavated to the thill of

the seam, and a brick wall, 2 feet thick, was built therefrom to the hard roof of the drift, care being taken to rip down any of the rock that appeared to be "drawn." The wall was then continued back until it joined the shaft-pillar. This wall was backed with a thickness of 2 to 3 feet of sand, the bottom also was filled with sand to within 6 feet of the roof, and the driving of the drift resumed.

When the cross-road or No. 1 jinney was reached, fire was again encountered. A stopping was built in the road on the left-hand side of the drift, and the bottom of the drift was taken out from *E*, onwards, the wall and sand-backing being continued to the face of the drift on both sides.

The driving of the drift was then resumed in the coal, the roof being taken down to the hard top stone, about 18 or 20 feet high, and all the hot coal was abstracted to the level on the right-hand side of the drift, the space being packed as tightly as possible with stone and sand. The walls on both sides were kept as near the face of the drift as possible. As the drift advanced the fire became worse.

By the time *B* was reached, the whole of the excavation was red hot up to the fault. At this point, a stone-drift had been driven through the fault to win the seam above. A brick-stopping was built in the cross-drift at *A*; and the fire having passed up it and ignited the coal on the rise side of the fault, a heading was driven round this fire, and a wall, backed with sand, 2 feet thick, was built to confine it. This road was kept open for the purpose of enabling an examination to be made, and to allow of ventilation to cool the wall. At intervals round the wall, ½ inch tubes were inserted, and through these water was poured continually upon the fire. The area enclosed by the wall was about ½ acre in extent.

When the old goaf was reached at *F*, it was found to be very solid, and the fire not having penetrated into it, the walling was discontinued. No evidence of fire was observed while crossing the old goaf, but immense volumes of carbon dioxide were liberated, whenever an old gate-road was encountered. Great difficulty was experienced in keeping the atmosphere clear enough of this gas, for men to work therein, although about 120 cubic feet of air per minute was forced through pipes laid alongside the drift to the face. This gas poured out of the crevices in the sides of the road for several weeks after exposure. After the drift had joined a heading driven in the coal round the old workings, a current of 40,000 cubic feet of air per minute was passed through it.

Soon after this connexion was effected, stink was evident at *G*, and a heading was driven towards No. 1 jinney. After this had been driven about 60 feet, fire was found in breaks in the coal, and the whole of the coal over an area of about ½ acre was worked until it was found to be cool. Subsequently, portions of the wall on both sides of the drift from *B* to *E*, frequently became hot, and were broken into, so as to remove the fire from behind.

On one occasion, an excavation had been made for a length of about 9 feet. About midnight, a man was engaged filling hot dust out of it, when about a shovelful of sand fell from above upon his head. The man immediately went out and sat in the drift, and after some minutes complained to his mate that he felt faint and ill. As he did not appear to recover, his mate took him out of the pit and so home. A doctor, who came to attend to him, found him lying unwashed on a sofa; he told him to wash and go to bed, and that he would send him medicine. When the medicine arrived about an hour afterwards, he took the prescribed doses, but remained on the sofa. His mate on leaving work about 6 a.m. called to see how he was getting on; he replied that he did not feel much better, and almost immediately sighed and died. At the inquest the doctor stated that death was the result of carbon monoxide poisoning, and a verdict was returned accordingly.

This death is the only instance resulting from the effects of this gas in the operations conducted under the direction of the writer. Frequently, men, after working at a fire, have appeared to recover after being about 20 minutes in fresh air, and then suddenly become unconscious. Such is the dangerous character of this gas, and special care must be taken to prevent workmen from inhaling it.

(3) *Fire Occurring in a Waste* (Fig. 2, Plate VI.).—Two districts of workings had approached each other from opposite directions, and the "wastes" having broken behind each face, the roof strata remaining were supported by the last rib of coal, *G*, preventing the goaf from becoming solid. Consequently, the space remaining around the rib of coal allowed of the admission of sufficient air so as to cause oxidation of the coal, but insufficient to carry off the heat generated. The temperature gradually increased until the incandescent point was reached, and then rapid combustion ensued. The first indication was the usual smell of distillation at the point, *A*, on No. 17 gate-road. An airway (No. 66 level) allowed of the quick laying of a tram-road and water-pipes, so that tubs were soon taken to the point, *A*. Here, the end of an old road, *B*, and the

place A C, were standing open and full of white-damp. While the work of clearing the road from K to A was in progress, a road was scoured from E to C. In the meantime, water was put on the hot goaf at C, which caused white-damp to pour out at B, upon the workers at C, some of whom were temporarily overcome but extricated by their fellows, and for some time a pulsating issue of this gas was noticed from B to A. A man was therefore appointed to watch the point A, and when the white-damp began to move all the men were withdrawn from the place C. When the junction of the places C and E was effected, the white-damp was quickly cleared away and the fire brightened. It was now possible to get near the fire and to damp it down with water, of which the pipes (1 inch in diameter) laid from the shaft afforded an ample supply. The work gradually progressed towards G, where a small pillar of coal was found. Roads were scoured round and through the seat of the fire, now cooled by water, to H at the bottom of the 18 feet fault. The working out of the broken tops coal and the running of the small broken shale and bind lying above it, exposed the face of the fault up to the coal-seam, and another pillar of coal, I, was discovered. This pillar was removed after the fire was extinguished. The roads driven and scoured, enclosed the heated ground, and cut it up into small blocks, allowing of the free circulation of air through and round it. No indications of fire have since been evident in the vicinity. Fig. 3 (Plate VI.) shows a section of the Barnsley coal-seam and the strata immediately overlying it.

The coal is worked on the longwall system, the gate-roads being spaced 120 feet apart, and supported on either side by stone pack-walls 7½ feet wide, built up to the tops coal. Behind the gate-road pack-walls is a waste 21 feet wide; then a pack-wall 6 feet wide, also built up to the tops coal; then another 21 feet waste and 6 feet pack-wall; and so on. Thus there are 4 wastes each about 21 feet wide, and 3 pack-walls each 6 feet wide, between each gate-road. Owing to the very friable nature of the shaly bind, varying from 8 to 18 feet in thickness above the coal-seam, the tops coal is not worked in the stalls, but is propped up by timber and supported by the pack-walls. After a fall has been taken off the face, new timber set, and the pack-walls advanced, the rows of back timber are drawn, allowing the tops coal to break into the wastes; and this is usually followed by a large amount of the shale lying above the coal-seam. All the available coal is then taken out of the goaf, but that over the pack-walls is so crushed that it is abandoned, and in fact it would be dangerous to attempt its extraction. The rock, lying above the shale, gradually bends or breaks down in large masses, and the goaf

ordinarily soon becomes solid and airtight. The conditions, however, are different when two workings approach each other, for then the broken roof falls back, each way, and is at last supported in something like the form sketched (Fig. 3, Plate VI.). The old workings remains very open for a considerable time, the bind and shale at the junction forming merely a light covering over the broken small coal left among the pack-walls, abandoned props, and ribs of coal, if any.

Then occurs a condition under which spontaneous combustion originates. By the arrangement of doors, sheets or falls in wind-roads, intake or return airways, it may be possible to force sufficient air into the open waste so as to cause oxidation of the broken coal, but insufficient to carry off the heat generated, and then the trouble with fire begins.

It will be fairly easy to deduce the cause of the outbreak from the explanation of the situation of this fire and a reference to the plans.

(4) "*Roundabout*" *Fire extinguished in* 1892.—After the last-mentioned fire had been successfully negotiated, it was decided to attempt to extinguish the fire which was walled round as previously described (2), and was continuously a source of anxiety and danger. The remnant of the walls, *A N* and *E F*, built to restrict the fire, are shown in Fig. 4 (Plate VI.). This effort proving ineffectual, on account of the heat working through fissures in the roof and igniting the surrounding coal, it had been again confined by the walling, *H D K G*. The passage was well ventilated and inspected twice during every shift, and every crack which allowed air or gas to pass, was carefully plastered. Notwithstanding the long period that had elapsed since the fire was sealed, the heat of the wall and in the passage indicated that the fire was in no way abated.

Entries were made at *A*, *B*, *C*, *D* and *E*, and the fire, where found, was damped down and filled out. The hottest part was found at an old brickwork arch, where the heat was so intense that coke-rakes, 15 feet in length, were used to rake the mass down, in order to throw water upon it. The water was sparingly used, as the strata were so hot after about 15 years of burning, that when cooled too quickly there was danger from falls. Gradually the area of the fire was limited, all the coal, possible to get, was filled out, brickwork pillars were built to assist girders in supporting the roof, and the whole area of the fire was honeycombed with passages.

The cooling down to normal temperature took many months. A thermometer hung in the return airway, near *K*, registered 90° Fahr.,

but the temperature is now normal. The thick lines indicate walls and headings driven to get at the fire, and the thin lines show the old workings.

(5) Not long after the above fire was cooled, another was found at *M*, among the slips of a fault on the opposite side of the drift (Fig. 4, Plate VI.). This was followed into the coal, until it reached some stables (which had been arched) and an old level filled with *débris*. This fire was very quickly got under. Headings, in the coal, were driven enclosing it, then the heated portions were attacked in detail, and cooled down.

(6) Fig. 5 (Plate VI.) is a plan of a portion of the extreme dip workings where a fire occurred at *F* during a strike of the workmen in 1885, and *B A C* was the line of face of some down-hill stalls. The ventilation took the course indicated by the arrows down the engine-plane, and along the working-faces.

A fall occurred at *A* and before the obstruction could be removed, the coal and shale in the fall became ignited and set fire to the solid coal. No pitmen could be prevailed upon to render any assistance (owing to the strike), and efforts were made for a fortnight with the help of surface-hands to subdue it. The air and smoke were turned by the nearest direction to the airway, *D*, and the fire attacked from *C*. For about 120 feet, along the face, the passage was so small that it barely afforded crawling room, and as this was the only access to the seat of the fire no time could be spared to enlarge it, especially as it was liable to falls which might have imprisoned the men who were endeavouring to make a communication with the gate-road, *A*. The fire spread with such rapidity that it was eventually decided to flood the district with water syphoned from the river by the steam-pipes feeding the underground hauling-engine, from which they were disconnected at the bottom of the shaft. When the workings were inundated to the level marked "flood-line," the fire was extinguished.

During the operations, difficulty was experienced in keeping the air passing through the fire from becoming explosive, by reason of fire-damp mixing with it. No other air-course being open, all the ventilating current of that portion of the workings had to be passed through the fire (and acted as a blast on a furnace), and the volume of air was limited by the fall to such an extent as only to just sufficiently dilute the fire-damp given off. The wisdom of providing an alternative course for the the ventilation in all parts is clearly apparent.

(7) Fig. 6 (Plate VII.) represents a place, where a fire occurred in 1894. A new airway was being driven through the goaf, a rib of coal was approached, and before it was reached, it took fire. The openings made into the seat of the fire are shown by thick lines. The roof was very bad, and although iron piles were driven into the loose *débris* to keep it up, falls were frequent, and slow progress was made. The shale was of an oily character, it burnt perhaps more freely than coal, and emitted a very poisonous gas. This was particularly so in this case, perhaps owing to the small extent of the workings, surrounded by goaf on all sides, and the shale and coal were crushed very small.

(8) Fig. 7 (Plate VII.) shows the situation of a fire which originated in 1895 during a strike of the surface-workmen. The pitmen were available for the work. A rib of coal had been left, and a new working approached it along the side of the goaf.

(9) In another case, a wedge-shaped piece of coal 4 feet wide at one end, pointed at the other, and 7 feet long, had been left between two faults at the split, (Fig. 8, Plate VII.). An airway was cut through the base in line with an advancing stall, the coal fired at the smaller fault, and ignited the *débris* on the intake side. The means adopted for isolating and extinguishing it are shown by the thick black lines.

(10) Fig. 9 (Plate VII.) shows a narrow piece of coal which was being worked from two directions at right angles to each other, so as to get it quickly removed and reduce the chance of fire. The roof would not stand this system, and No. 45 stall fell in before the rib, *A*, could be removed. An attempt was made to open No. 46 stall round the top side of the rib. A heavy fall occurred at *B*, stopping the ventilation, and before this could be restored, a fire broke out at *C*, while No. 45 stall was filled with fire-damp at *D* and black-damp at *E*. The fire burnt until the whole of the rib of coal was removed.

(11) In this case, (Fig. 10, Plate VII.), the old workings had been closed for 3 years and it might have been supposed that they had become settled. The smell of fire was first noticed at *A*, and the following day at *B*, proving that there were two communications for air. Roads were driven in order to surround the fire completely, and it was then cut up and filled out. The fire was discovered on July 27th, and operations were completed on August 30th, 1899. Three shifts, of 14 men in each, were engaged in its removal.

(12) Very shortly afterwards, another stink or smell of fire was found at *M*, and the usual enclosing roads being driven (*M N*, *O P*, and *N P*) and joined, the fire was found at the foot of a pack-wall. As the roof-shale was very loose, roads were made upon the top of it, under the rock, and a plentiful sprinkling of water prevented the heat from spreading. This fire was extinguished in 10 days, on October 28th, 1899.

(13) Fig. 11 (Plate VII.) represents a portion of the workings in the east engine-plane district where a fire occurred in 1896. A faint smell as of paraffin was observed at *A*, and a scouring was immediately commenced in order to locate the source of the trouble. When the pack-wall was penetrated, the goaf was found to be broken up to the hard rock, and full of white-damp. Another road was scoured from *B* to *C*, which, although very hot, produced no further evidence of fire, although it spread to this road afterwards. As the latter road progressed a communication was made, at *E* and *G*, into the open goaf in order to clear it. When this was effected, the road, commencing at *A*, was pushed forward over the broken-down shale, and water freely poured upon the hot *dèbris* below. On the road, *B C*, reaching the old goaf, which was solid and cool, the scouring was continued to *D*, where a rib of coal was encountered. This had not taken fire, but the whole of the ground on the right-hand side of *C* and *D* was red hot, and as the only means of ventilating it was by bratticing, it rapidly filled with smoke, so that it was no longer possible to work in it, or even to make an inspection beyond *G*.

Another road was commenced at *I*, over the fall, to *H* where the roof-shale was solid; and a descent was driven from that point to *D* with the object of providing ventilation around the enclosed area. It was found, however, that the fire had ignited the timbers from *C* to *D*, and the road was closed. A communication was then made, by way of *I J* to *K*, through the fire, iron piles and girders being set to maintain a road. The portion thus enclosed by the roads, *A B K J*, was then cut up and the fire remaining between the excavation was extinguished by the application of water. Great difficulty was experienced in carrying out this portion of the work on account of the great heat and smoky atmosphere; immense falls of rock greatly impeded progress, and some large blocks were lifted back by hydraulic jacks, as it was too dangerous to attempt to break them up, owing to the risk of loose ground falling in.

The ventilating-current was frequently reversed, in order to enable the men to work sometimes from one side and sometimes from the other.

After the fire was diminished from *B* to *K*, the place *K C D* was reopened and the enclosed fire taken out in detail. Fire in the meantime had been found on the right-hand side of *I H*: *L M* and *F M* were driven on the floor-level. This was afterwards continued to *N* and across to *D*, meeting the road *H D* from over the fall at the latter point. The fire was then found to be completely enclosed, and ultimately was partly extracted, the remainder being slacked with water. The whole of the fire was extinguished before the rib of coal was touched, and it was found on being worked out not to have been attacked by the fire.

About 60 men per 24 hours were employed at the fire for a period of some 3 months. About 600 iron piles, made from 18 lbs. pit-rails, 6 feet long, were used, and a set of 4 men were occupied for about 6 months in taking out the timber, girders and piles after the place had cooled to a normal temperature.

In all these fires at Denaby Main colliery, although it was seldom that any of the colliers were willing to assist, it had been the writer's good fortune to have fillers and datallers who would follow a leader into the worst parts, and work at the fire while suffering intense headache, and to this bravery may be attributed the speed with which some of the fires were overcome.

(14) Fig. 12 (Plate VII.) illustrates outbursts of fire at the Cadeby colliery in November, 1898. A narrow rib of coal, *A*, had been left at the low side of a 60 feet fault. The shale-roof, about 18 feet thick, was very bad, and difficult to work under. All the roads were piled. The air-current found a passage, from the drift, through loose ground, being drawn towards the return airway along the coal-face.

(15) Fig. 13 (Plate VII.) shows the position of a fire, which broke out at Cadeby colliery, close to the shaft-pillar, and spread into it, along breaks caused by the crushing weight. Headings were driven to the back of the fissures, which were filled with mortar and sand. The headings were then tightly stowed with small stone, and the main level was ripped in order to bury the coal. The small bind used for this purpose was afterwards well drenched with water, in order to make it solidify.

(16) Fig. 14 (Plate VII.) illustrates a fire at Cadeby colliery. In this case, the first indication was a smell, as of paraffin, at *A*, in an old airway, *A D*, in which a fall had occurred at *D*, blocking the air: so the

airway, *A D*, was "drawn off," and a new one, *D E*, scoured. The smell was traced to *B*, and the place *B C* was at once commenced. When 18 feet were scoured, the roof gave way and the broken and exceedingly loose bind began to run in. An attempt was made to get over it, and for some days men were continually engaged in removing the *débris* which was sent out of the pit. Two other roads, *F G* and *I K*, were started in order to surround the heated mass, and a third place, *L M*, so as to remove the smoke which interfered with the men working, and air-pipes (19 inches in diameter) were placed near the roof of *M N* (Fig. 15). Water was copiously poured on the heated mass, *C*, from all sides. The fire was thus much reduced, and rapid progress was made in its extinction. A chargeman was present with each shift continuously, who every ½ hour tested the return airway and the top of the opening, *N*, for gas. On March 11, no gas was found, but a "weight" was felt and a bump heard, as a large piece of rock broke at *O*, falling upon the top of the mass, *C*. This must have liberated gas and forced it through the wet *débris*, *C*, and an explosion took place, burning 2 men at *M* and 2 others at *P*. The deputy, at *B*, felt the shock, but was not injured, although his safety-lamp was extinguished. The 2 men who were with the deputy went away to the pit, and he went round by the windroad, *Q*, without a light to ascertain how the other 2 men had fared. He found them severely burnt, and immediately went for assistance. These 2 men unfortunately died after their removal to the Mexbro' Hospital.

Half an hour after the explosion no fire could be seen, and after a thorough examination no vestige of gas was found. The road *F G R* was connected under the old goaf with *I K R*, but the fire, quickly cooled under *C*, broke out at *K*. The place *R S* was then driven, and water poured all over the heated mass. At the same time, roads were driven across, supported by 6 feet props and notched cross bars, with 6 feet rails pointed for piles driven above and ahead of them. The props were set as closely as possible, and covered with boards. No further running in of the roof occurred, and the work went on steadily until the extinction of the fire.

In this case, the "tops coal" did not burn, except where broken and loose, through props being left in, and the greatest heat was produced in the white-hot mass of shale lying above it.

From the instances enumerated in this paper it is apparent that outbreaks of fire are to be apprehended until the goaf is completely settled; and that, when it becomes solid and the air is completely

excluded, there is no danger. It becomes obvious, therefore, that, as far as practicable, the extraction of the coal should be made by long faces of longwall working and advancing in one direction, and leaving no pillars of coal or timber which would prevent the settlement of the roof. The greatest difficulty experienced is that stalls, working under a bad roof, frequently fall in, and these being headed out with a narrow strip of coal next the goaf, when through are liable to fall in again before the strip of coal can be taken out. The colliers nearly always try to mislead the deputies by stating that pillars are removed, when in fact they are not. Frequently also, when a pillar has been reduced to small dimensions and difficult to work, the colliers will deliberately bury it when a favourable opportunity arises, and then inform the deputies that the coal has been filled out. Inspection at frequent intervals is the only remedy, and even then occasionally the deputy is deceived. When this happens, a discovery is nearly always eventually made through the occurrence of the resulting fire.

The trite proverb that a stitch in time saves nine is very applicable to underground fires. Immediately there is evidence of a fire, every minute wasted in locating and isolating it means perhaps many hours of labour under most trying and dangerous conditions. If it be desirable to obtain samples of the gases produced and the temperature of them and the strata, it should be done in such a manner as not to interfere with active operations—bottles and thermometers will not put out a fire; and it is of paramount importance to set workmen with shovels to work, and to keep them vigorously at it without cessation, until there is no longer need for their labour. Precious moments wasted, discount wonderfully the chances of success. Procrastination and sluggishness will certainly augment very greatly the risk and cost, and may entail the closing of a section of the mine, or the whole of the colliery. The failure to overcome a fire in its incipient stage has caused incalculable losses, when the fact of some having spread over vast areas is considered.

In the Tawd Valley collieries, at Skelmersdale, a thickly seamed coal-area between Liverpool and Preston, a fire broke out which resisted every effort to subdue it, and several men lost their lives while attempting to extinguish it. It was ultimately drowned out by turning a stream of water from the Tawd river down the shaft; this served its purpose, but caused enormous damage to the workings of the colliery. In 1872, when another fire occurred, to avoid the ruinous expense entailed by flooding, it was decided to prevent its encroachment upon other parts of the mine by enclosing it by masonry walls. But the heat

of the fire cracked the walls; and after years of labour and anxiety, involving costly expenditure in the building of walls, in 1897, the fire was again extinguished by the bursting of the banks of the river Tawd, which allowed the water to pour into the doomed workings, ruining the colliery and thus ending a struggle which had continued for 25 years. Other similar conditions are, or have been existent in Ayrshire, Warwickshire and Lancashire.

How important, then, is it to exhaust every means and effort to extinguish utterly a fire occurring in a mine, before resorting to an attempt to prevent its encroachment by walling, etc., and then leaving it to smoulder on!

It is the earnest conviction of the writer that if the opening out of the old workings, described at the commencement of this paper, had been delayed for 3 months, the Denaby Main colliery would have been lost for ever.

Mr. I. Hodges (Whitwood colliery) said that, from his experience of gob-fires, he could endorse Mr. Chambers' opinion that the only radical method which could be adopted was to fill out the fire. Fires which had been bricked round for years had gone on increasing in temperature, although practically not increasing so much along the roadways as at the seat. He was also of opinion that, in every case in which a gob-fire had been properly located, props left behind in the goaf, or ribs of coal left against faults, or falls in bank-headings had been the cause of fires. At a colliery with which he was connected, when a stink was found, all speed was made to the place where the fire was expected and it was at once filled out. With a hard strong bind-roof, there were no fires, but with a soft oily shale-roof, fires were frequent. Wherever a prop was left in the waste a fire occurred. He could only confirm what Mr. Chambers had said, that the colliery-manager was indebted to the datallers and bye-workmen for rapidly following the official of the colliery into situations of great danger. In his experience he had not found that the colliers themselves lent much aid for the preservation of even their own stalls.

Mr. Walter Hargreaves (Robin Hood collieries) moved that the thanks of the members be accorded to Mr. Chambers for his valuable paper.

Mr. J. L. Marshall (Monk Bretton colliery) seconded the resolution, which was cordially adopted.

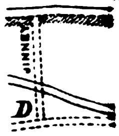
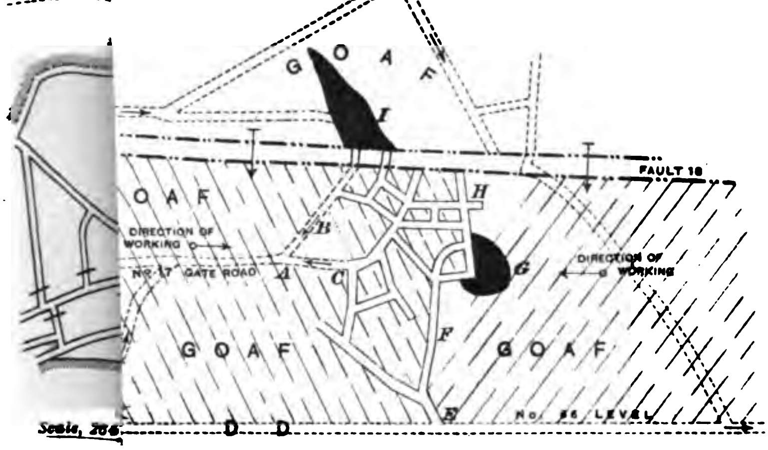


FIG. 2.



Scale, 132 Feet to 1 Inch.

FIG. 4.

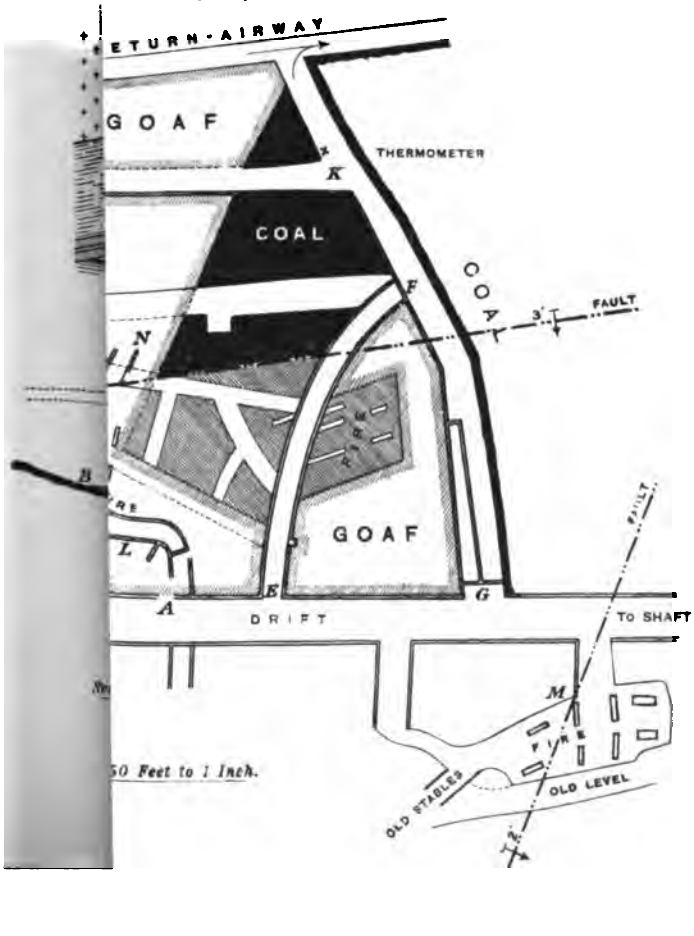


Fig. 9.

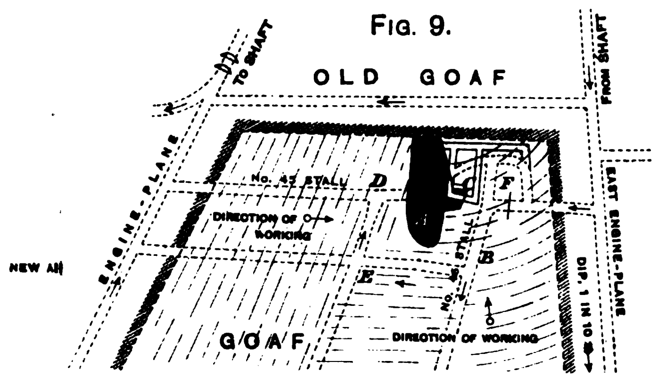


Fig. 8.

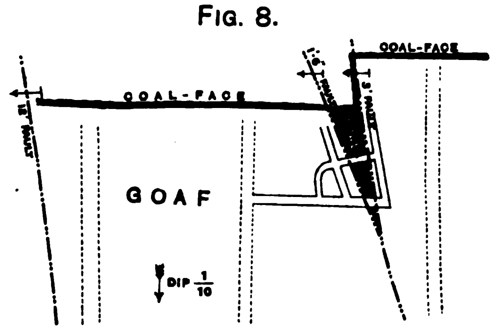
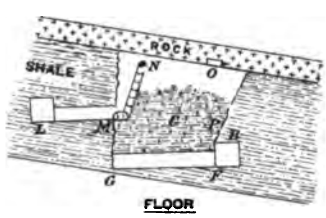
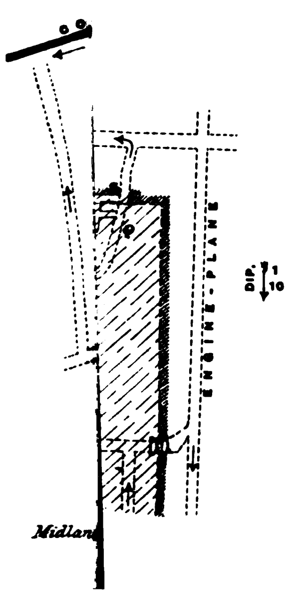


Fig. 15.



Section on Line L B of Fig. 14.

Scale, 30 Feet to 1 Inch.



References.

Faults and Direction of Throw

Direction of Ventilating-Current.

Ventilation Doors

Ventilation Sheets or Stoppings

Direction of Working of Coal

Dip of Seam

Scale. 200 Feet to 1 Inch.

The PRESIDENT (Mr. W. H. Chambers), in acknowledging the vote of thanks, said that gob-fires constituted one of the hardest tasks with which a mining-engineer could have to deal. Water was found in the lowest place, but they might have fire for several weeks after they perceived the smell, and they would find it many hundreds of feet distant from where they expected to find it. It was certain that, as the workings became deeper, and the normal temperature of the mine increased, that there would be greater risk of these fires occurring.

The discussion was adjourned.

DISCUSSION OF MR. L. T. O'SHEA'S PAPER ON "THE SAFETY OF MODERN MINING EXPLOSIVES, WITH SPECIAL REFERENCE TO METHODS OF TESTING."*

Mr. L. T. O'SHEA (Sheffield) wrote that the Home Office had recently issued a notice of an additional test to which explosives already upon the "Permitted List" might be subjected. The proposed test was more severe than the original one, and explosives which passed it would be placed on a "Special List." The chief feature of the new test was the increase in the weight of explosive to be used. Two series of experiments of 10 shots each were to be made, with weights equivalent to 3 and 4 ounces of dynamite (75 per cent. of nitroglycerine) for high explosives, and 9 and 12 ounces of R.F.G_2 powder for explosives of the gunpowder class. No explosive could pass the test that produced a single ignition in the 20 shots. This was a first step towards the classification of explosives, and while viewing with some satisfaction the institution of the special test, he proposed to offer a few criticisms on it as an introduction to the discussion on his paper. There was no doubt that the test was more severe than the original one, but the objections raised to the use of a fixed weight in the case of the original test applied equally to the special test, namely, that the use of a fixed weight placed all explosives that passed the test on the same level, and there was no guarantee that safety was assured if that weight were exceeded in actual working. It would be more satisfactory to adopt a rising scale of weights, and ascertain the maximum weight of each explosive which would not ignite the gaseous mixture in a definite number of successive shots.

* *Trans. Inst. M.E.*, vol. xvii., page 189 ; and vol. xviii., page 77.

The test also appeared wanting, inasmuch as no experiments were to be made with coal-dust. Seeing that the explosives are permitted for use in coal-mines, and that the presence of dust greatly increased the sensitiveness of gas to ignition, it was highly important that the safety of explosives in dusty atmospheres should be tested, and by the omission of such experiments the value of the test from the coal-miner's point of view was greatly lessened. He had already pointed out that the method adopted at Woolwich of testing in dusty atmospheres was quite unsuited for the purpose, but he hoped that the Home Secretary would see fit to introduce some test of this character in a horizontal chamber, especially with those explosives placed on the special list. Without such tests it was possible that an explosive highly dangerous in dusty atmospheres might find a place even on the special list.

It would be more satisfactory if pit-gas could be used instead of coal-gas in these tests. Of course this was impossible at Woolwich, but it was possible to manufacture marsh gas and mix it with other gases so as to resemble pit-gas, and the resources at the command of the Home Secretary should enable him to do this. He had little doubt that the use of coal-gas in so small a gallery greatly restricted the weights of the explosives that could be used within narrow limits, owing to the ease with which coal-gas was ignited, but marsh gas or pit-gas was much more difficult to ignite and its use would, doubtless, allow of larger charges being fired.

The size of the gallery had been fully criticized in his paper, and since its publication he had, through the courtesy of H.M. inspector of explosives, had the opportunity of visiting the Home Office testing-station. His opinions, already expressed, were fully confirmed, and, in addition, he doubted whether experiments on the scale advocated in his paper could be carried out in so small a gallery.

Mining-engineers in this district should consider whether they were content to accept a test which had been condemned as unsatisfactory, or to investigate the question on their own account in a manner calculated to give more satisfactory information. He felt sure that the Home Secretary would look upon such experiments with favour, while the results, though not supplanting the official tests, would serve to guide the colliery-manager in making his selection of an explosive from the official lists. Additional advantages would be that the results would be published, as was done in Germany, so that the record of each explosive would be known, and the explosives for testing would be bought in the market from the stocks supplied by the makers to the mines.

The President (Mr. W. H. Chambers) said that Mr. O'Shea had emphasized, and he thought that the members could not but agree with him, the necessity of establishing a testing-station where explosives could be experimented upon as nearly as possible under the conditions in which they were used in mines. He thought that the members would be pleased to see a station established with proper apparatus, on such a scale that they could test explosives for themselves, not for the purpose of putting it in the place of the test carried out by the Home Secretary, but of supplementing it.

The further discussion was adjourned.

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING,

HELD IN THE MASON UNIVERSITY COLLEGE, BIRMINGHAM, DECEMBER 4TH, 1899.

MR. JAMES LINDOP, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting and of Council Meetings were read and confirmed.

The following gentlemen were elected:—

MEMBERS—

Mr. EDWARD DE LACY, Germiston, Transvaal, South Africa.
Mr. WALTER L. WHITE, B.A., Mining Engineer, Penzance.

STUDENT—

Mr. WALTER L. E. GORDON, Mining School, Camborne.

Mr. ALEXANDER SMITH (M.Inst.C.E, and Secretary of the Institute) read the following paper on "The Rating of Coal-mines":—

THE RATING OF COAL-MINES.

By ALEXANDER SMITH, M.Inst.C.E.

This subject has recently received considerable attention, and the object of the writer is not to propose and expound any new method of arriving at colliery assessments, as he cannot suggest any radical improvement upon the system of taking an estimated royalty, either including an amount for what is legally termed the "planting of the mine," *i.e.* the plant, shafts, roads, etc., or with a sum per ton for these added. This is now pretty generally in vogue; as a rule it works well, and gives satisfaction to all parties.

It is, of course, assumed that there is a reasonable Assessment Committee, and a fair and competent assessor who takes all the circumstances of the district and of the particular mines into consideration.

The writer would here suggest that, in his opinion, a more satisfactory and less costly court of appeal than the Quarter Sessions would be a technical arbitration-board, formed on the lines of that appointed by the South Staffordshire Mines Drainage Commission, consisting of a barrister, a civil engineer and a mining engineer, who sit and graduate the rate in accordance with the special circumstances laid before them in evidence.

The object of this communication is to comment upon, and form part of the discussion upon, the innovation strongly advocated by three leading rating authorities, of treating colliery assessments in the same way as special properties and monopolies, and rating upon the accounts.

This departure was first prominently introduced by Mr. G. Humphreys-Davies in a paper read before The Institution of Mining Engineers* and further pressed in the recent paper read at Sheffield by the same author.† Mr. E. J. Castle, Q.C., gave a paper upon the same lines in 1894,‡ and Mr. Edward Boyle, Q.C., read a very complete paper which was followed by a good discussion at the Surveyors' Institution in January, 1899.§ These three gentlemen are authors of well-

* *Trans. Inst. M.E.*, vol. iii., page 773.

† *Ibid.*, vol. xviii., page 228. ‡ *Ibid.*, vol. vii., page 428.

§ *The Surveyors' Institution, Transactions*, vol. xxxi., page 143.

known treatises upon rating, and they have a large practice in rating appeals, but the writer wishes to consider the question from the point of view of one who has had considerable practical experience both in colliery rating and leasing.

The outcome of the introduction of this innovation has been the Denaby case, quoted by Messrs. Boyle and Davies, and that case must be considered, although it does not, from the way it was stated, settle the point or, in fact, govern it to any material extent.

Messrs. Boyle and Davies were professionally engaged in the case for the appellants, and no doubt found it a favourable opportunity for utilizing their pet scheme, that the best and fairest method of arriving at the net annual value was that of ascertaining the receipts in the year and then deducting therefrom the expenses, allowances for tenants' capital, etc. The case was referred to the arbitration of Mr. Littler, Q.C., and this method would receive especial favour from him, as he is thoroughly conversant with it from the many large appeal cases, connected with railways, waterworks, gasworks and other special properties, in which he has been engaged; and, not being technically acquainted with mining details, the usual custom of going on the royalty and considering the mining circumstances would present exceptional difficulties.

He therefore stated a special case, asking amongst other points whether the evidence of the accounts was admissible. Mr. Justice Day said:—"As the case was exceptional and to be dealt with exceptionally, the evidence was admissible." Mr. Justice Phillimore said:—"I am of the same opinion. I think it must be taken from the findings of the arbitrator that this colliery is such an exceptional colliery that the assessment can only be arrived at by the method applied to what are called exceptional cases, and therefore the evidence put forward by the appellants is necessarily admissible."

It is quite clear, therefore, without further comment, that this judgment can have no bearing upon colliery assessments generally.

Now, to refer to the papers more particularly, it is only necessary to take the two recent papers by Messrs. Boyle and Humphreys-Davies, both read since the Denaby case. Both authors give the usual dissertation upon the acts that govern rating, beginning with Elizabeth and ending with William IV. Mr. Humphreys-Davies says that the assessment of a colliery cannot be based upon the rent or royalty, and a consideration of the risks and advantages of the past year, because the law contemplates a rent fixed in advance and not a variable rent fixed in

arrear; but surely this is an argument that cuts both ways, and tells equally against the scheme for fixing the assessment upon the accounts of the last year, as those for the following may vary as the other items do, and be either much better or worse.

Both gentlemen point out that the coal *in situ* is not rateable because it can produce no profit, and is equally not rateable when it is worked or gotten, as then it becomes stock-in-trade, as one puts it, or chattels, as classified by the other. This is really begging the question; and the line of argument, although perhaps ingenious and interesting, can have no effect upon the Assessment Committees and the courts.

It is the beneficial occupation of the area worked that is rated, whether it be estimated by the acre, foot thick, or ton, as the surface is rated in the case of a farm. It may be contended that the farmer does not exhaust the land as the colliery-owner does the coal; but as a fact he does, and uses up certain constituents of plant-life which must be replaced by means of manures and tillage of the soil to expose it to the effects of the atmosphere, or it would cease to be profitable. The only difference is that the coal cannot be replaced.

In both papers also the old contention is reproduced that a rate should not be imposed upon the coal obtained, because it is part of the realty and an exhaustion of the *corpus*. Both quote the case of Rex *versus* Attwood, and Mr. Humphreys-Davies, after putting a peculiar construction upon that case, says that the decision is obsolete, as it was given in 1827, prior to the passing of the Act of 1840, exempting stock-in-trade from rating. It is surprising that this view is expressed, as Mr. Boyle, who is Mr. Humphreys-Davies's partner in authorship and a legal expert of considerable experience in rating, in his paper read eight months previously, shows that instead of the case becoming obsolete, it was confirmed in 1847, *i.e.*, after the passing of the Act of 1840, in Regina *versus* Westbrook, in which it was held that the payment in respect of brick-earth was not the less a rent because the subject-matter of the renting was in course of being wholly consumed. Mr. Boyle winds up this part of the discussion with this most sensible remark:—"It may at any rate now be considered as decided that no deduction is to be made between the gross and rateable value from the fact that a coal-mine is gradually worked out and ultimately becomes valueless."* Therefore, as the latter portion of the judgment in Rex *versus* Attwood reads, "The legislature has expressly made coal-mines rateable, and they must

* *The Surveyors' Institution, Transactions*, vol. xxxi., page 148.

be rated for what they produce, viz., the coals," it may be taken that Mr. Boyle finally disposes of all the arguments adduced by Mr. Humphreys-Davies as to the rating of stock-in-trade, deduction for replacing the capital value, and treating a colliery as an underground railway.

Now, coming to the main question as to the substitution of the method of assessing a colliery on its accounts for the one generally in vogue and before described. The difficulties of working upon the latter system are considered to be enormous, and no doubt they are to an untechnical mind; but they are more imaginary than real, especially to the mining expert. It is stated that no mines are let by the year, but this is not the case, as it is not uncommon in Staffordshire to let pits even by the week. It is said that, because of the different circumstances in each mine, no comparison can be made; but, as a matter of fact, the royalties and terms for leases, which are much more important than assessments, are based upon comparisons, if not with mines in the same district, at all events with those in others. It is all a question of knowledge and experience, and nowadays the agents of both landlord and tenant can make a fairly good forecast as to how a mine will turn out. There is, of course, always a certain amount of speculation, but it is not often sufficient to affect materially the future of a colliery, taken over the whole of its life.

It is contended that collieries should be treated as special properties, and this being accepted, why not other properties? leading to a general rating of profits, which the law forbids. Special properties stand quite alone: they are regulated by their own particular Acts of Parliament; they are mostly monopolies; they are authorized to regulate their charges so that a regular and fair profit is ensured; they are never let by the year; and they are bound to publish very complete accounts, so that it is easy to find from their stable character what a tenant might reasonably be expected to pay from year to year.

Collieries from their very speculative nature are the very antipodes of these. Although, taking their whole life, collieries generally pay fairly well, yet taken from year to year their profits see-saw between two extremes. As an example of this, the annexed table contains a list of dividends of the Lofthouse colliery for 22 years, taken from *Burdett's Official Intelligence*.

It will be seen that the dividends range from nothing to over 36 per cent. taking into consideration the repayment of capital, yet the average is under 10 per cent. for the whole period, which is certainly good, but not too good, for property of the kind: the point, however, is to look at

the table and just imagine the fluctuations, the work for the rating authority and the worry for the colliery company, had the rating been on the accounts.

LOFTHOUSE COLLIERY. REGISTERED 1873.

TABLE SHOWING CAPITAL AUTHORIZED AND RAISED, AND THE DIVIDENDS PAID AND CAPITAL REPAID OUT OF NET PROFITS, AFTER PAYMENT OF ALL RENTS, ROYALTIES, AND OTHER OUTGOINGS.

1877, Capital authorized, shares, 20,000, at £5 = £100,000.
,, ,, raised, ,, 18,658, at £4 = £74,632.

	Dividends paid from profits of	Dividends Paid. Per Cent.	Per Share	Amount. £ s. d.	Capital Repaid. £ s. d.	Total. £ s. d.
1878	1877	Nil.	Nil.	Nil.	—	Nil.
1879	1878	$1\frac{1}{4}$	1/-	932 18 0	—	932 18 0
1880	1879	$3\frac{3}{4}$	3/-	2,798 14 0	—	2,798 14 0
1881	1880	Nil.	Nil.	Nil.	—	Nil.
1882	1881	5	4/-	3,731 12 0	—	3,731 12 0
1883	1882	$5\frac{5}{8}$	4/6	4,101 1 0	—	4,101 1 0
1884	1883	$6\frac{1}{4}$	5/-	4,664 10 0	—	4,664 10 0
1885	1884	$6\frac{1}{4}$	5/-	4,664 10 0	—	4,664 10 0
1886	1885	$7\frac{1}{2}$	6/-	5,597 8 0	—	5,597 8 0
1887	1886	$7\frac{1}{2}$	6/-	5,597 8 0	—	5,597 8 0
1888	1887	$7\frac{1}{2}$	6/-	5,597 8 0	—	5,597 8 0
1889	1888	$7\frac{1}{2}$	6/-	5,597 8 0	—	5,597 8 0
1890	1889	$8\frac{3}{4}$	7/-	6,530 6 0	—	6,530 6 0
1891	1890	$21\frac{1}{4}$	17/-	15,859 6 0	—	—
*1891	—	$12\frac{1}{2}$	10/-	—	9,329 0 0	25,188 6 0
1892	1891	$28\frac{4}{7}$	20/-	18,658 0 0	—	18,658 0 0
1893	1892	$27\frac{1}{7}$	19/-	17,726 2 0	—	—
†1893	1892	$12\frac{1}{2}$	10/-	—	9,329 0 0	27,055 2 0
1894	1893	$18\frac{1}{3}$	11/-	10,243 18 0	—	10,243 18 0
1895	1894	$18\frac{1}{3}$	11/-	10,243 18 0	—	10,243 18 0
1896	1895	$11\frac{2}{3}$	7/-	6,530 6 0	—	6,530 6 0
1897	1896	$6\frac{2}{3}$	4/-	3,731 12 0	—	3,731 12 0
1898	1897	$6\frac{2}{3}$	4/-	3,731 12 0	—	3,731 12 0
1899	1898	$4\frac{1}{6}$	2/6	2,332 5 0	—	2,332 5 0
				£138,870 2 0	£18,658 0 0	£157,528 2 0
Dividends paid, 5 years (1891 to 1895)				£72,731 4 0		
Capital repaid, 5 years (1891 to 1895)				18,658 0 0		
				£91,389 4 0	Average p. a.	£18,277 0 0
Dividends paid, 17 other years				66,138 18 0	,, ,,	£3,890 0 0
				£157,528 2 0	,, ,,	£7,160 0 0

* Capital repaid and shares reduced to £3 10s. † Capital repaid and shares reduced to £3.

Mr. Boyle gives the strongest evidence against the account theory when he says, "During comparatively recent years, coal has been sold at the pit's mouth at over 17s. per ton and at under 5s. per ton," and

further on speaks of "the speculative character of the undertaking."* On the account system there would be a large amount paid in rates when people were fully employed, and little or none in times of bad trade, when the poorhouses were full.

Mr. Boyle, at least, does not attach much importance to the Denaby case, neither does he show much faith in the new method, for after going most fully into both he winds up his paper with the following remark, "As a summary, I would suggest that any rating authority, desiring only to arrive at the true gross and rateable value of a colliery, should take into consideration all circumstances in connexion with the premises, including the cost or value of the shaft and rateable machinery, the age of the mine, the quality and quantity of the coal, the rent paid under the lease, the rents recently obtained under similar circumstances, the output, the prices obtained for the coal, and the expenses of producing and realizing it."†

As Mr. William Eve said in the discussion, this was exactly the principle upon which he had always acted, and which all other rating surveyors would, he was sure, accept. ‡

The writer in his experience had found that the assessors for the unions work on these lines and with generally satisfactory results ; in fact it is the present system to perfection.

Mr. J. A. Longden, then President of The Institution of Mining Engineers, as a leading mining-engineer and member of a colliery-district Assessment Committee, clearly showed in the discussion on Mr. Boyle's paper, that in addition to what had been adduced in this communication, the account scheme was neither practicable nor wise. It would require an army of valuers, followed by the lawyers and barristers in the appeals to carry it out. The rating authorities could never estimate their rates with any accuracy, and finally, the mine-owners would object to produce their accounts, excepting perhaps when it suited their purpose. §

There were two other points decided in the Denaby case—one, that the rent on lease was some evidence, but not binding, and the other, that when the rating authority had fixed the gross value the ratepayer was entitled to any statutable deduction that he could prove from it. In the case under discussion the net rateable value had been put in both columns, as the deductions were taken off before the royalty was arrived at, but in future the authorities will take care to make a gross valuation, which is really an absurdity, and not required, excepting by law.

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* *The Surveyors' Institution, Transactions*, vol. xxxi., pages 144 and 145.

† *Ibid.*, page 162. ‡ *Ibid*, page 165. § *Ibid*, page 162.

The PRESIDENT (Mr. James Lindop), after moving a vote of thanks to Mr. Smith for his able and valuable paper, said that it had always been considered that mines were over-rated, that the assessments were arrived at in a rough-and-ready way, and that the authorities only seemed careful to charge enough, which was, however, often too much.

Mr. W. J. HAYWARD, in seconding the motion, stated that varying ideas prevailed as to what should be the basis on which to rate a mine, and there were hardly two districts in which the rating authorities had adopted the same basis for rating. He wished to ask the writer of the paper whether the judgment in the Denaby Main colliery appeal was not given upon a case taken under the following circumstances. It referred to a seam of coal not previously worked in the district, and that fact constituted the exceptional circumstances.

Mr. JOHN FIELD said that it was a matter for complaint that the mode of assessment was different in various districts, and scarcely two Poor-law Unions were agreed as to the mode. The Assessment Committee, as a rule, was composed of grocers, butchers, and inexperienced men who knew absolutely nothing as to the value of a mine; and they appeared to be actuated only by the feeling that the more the mine was rated, the less they themselves would have to pay. Appeals were seldom made, owing to the excessive cost.

Mr. FRED. G. MEACHEM urged that the rateable value of mines should be assessed by a committee of experts, and, on this point, the suggestion made by Mr. Smith was very valuable.

The vote of thanks was then unanimously adopted.

Mr. A. SMITH said that Mr. W. J. Hayward was perfectly right in his interpretation of the decision of the court of appeal in the Denaby colliery case. It was a new colliery and it was contended by the appellants that there was no parallel case, but they, as mining-engineers, knew that sufficient information could have been obtained. The arbitrator very strongly adopted the former view, and the account-system was the one with which Mr. Littler was particularly well acquainted, and understood thoroughly. At one time, the system of assessing the rateable value varied in almost every district in the kingdom. In the Midland district they went on the lines which he had suggested in his paper, and most of the Poor-law Unions had followed that system. He advised owners, if they possibly could, to discuss and agree to an assessment with the professional assessor rather than bring the matter before an ignorant Assessment Committee.

The meeting then ended.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE, DECEMBER 9TH, 1899.

MR. WILLIAM ARMSTRONG, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting and reported the proceedings of the Council at their meetings on November 25th and that day.

The following gentlemen were elected, having been previously nominated :—

MEMBERS—

Mr. HENRY BENNETT, Mining Engineer, Rio Tinto Mines, Huelva, Spain.

Mr. SHERARD OSBORN COWPER-COLES, Electro-Metallurgist, Grosvenor Mansions, Victoria Street, Westminster, London, S.W.

Mr. DAVID DAVIES, Civil and Mining Engineer, Cowell House, Llanelly, South Wales.

Mr. JAMES ARCHIBALD DEWHURST, Mining Engineer, The Grove, Walton-le-Dale, Preston, Lancashire.

Mr. JOHN ENGLISH, Mining Engineer, Garesfield Colliery, High Spen, Lintz Green, R.S.O., Co. Durham.

Mr. JOHN SUTHERLAND FOSTER, Civil and Mining Engineer, Blaenau Ffestiniog, North Wales.

Mr. HENDERSON GIBSON, JUN., Colliery Manager, Chirton West View, North Shields

Mr. THOMAS CHICKEN HAIR, Mechanical Engineer, Bede House, Hebburn-upon-Tyne.

Mr. CHARLES HENDERSON, Colliery Manager, Cowpen Colliery, Blyth, Northumberland.

Mr. THOMAS HEWITSON, General Manager, Ivanhoe Gold Corporation, Limited, Boulder, Western Australia.

Mr. FREDERICK JOHN HOLMAN, Mining Engineer, The Grove, Walton-le-Dale, Preston, Lancashire.

Mr. FARQUHAR LAMBERT, Mechanical Engineer, Apartado 2025, City of Mexico, Mexico.

Mr. HENRY JOHNSON MEIN, Colliery Manager, Carterthorne Colliery, Toft Hill, Bishop Auckland.

Mr. ALEXANDER MONTGOMERY, Mining Engineer, Kauri Freehold Gold Estates, Limited, Opitonui, Coromandel, New Zealand.

Mr. ARTHUR MORT, Colliery Manager, Curran House, Dungannon, Ireland.

Mr. SAMUEL ROTHWELL, Colliery Proprietor, 21, Chorley New Road, Bolton, Lancashire.

Mr. JAMES HOWARD WALKER, Mining Engineer, Bank Chambers, Wigan.

Mr. NATHANIEL WILSON, Mechanical Engineer, P.O. Box 485, Johannesburg, Transvaal, South Africa.

ASSOCIATE MEMBERS—

Mr. JAMES GIBSON, P.O. Box 1026, Johannesburg, Transvaal, South Africa.

Mr. WILFRID INGRAM WRIGHTSON, Cramlington Colliery, Northumberland.

ASSOCIATES—

Mr. JOHN GEORGE STOKOE, Overman and Under-manager, 3, The Terrace, New Lambton, Fence Houses.

Mr. RALPH STOREY SWALLOW, Assistant Manager and Surveyor, Langley Park Colliery, Durham.

STUDENTS—

Mr. GEORGE HENRY ROBINSON, Jun., Mining Student, Holm Lea, Sunderland.

Mr. HUBERT F. G. ROOSE, Mining Student, 45, Hill Street, Berkeley Square, London.

DISCUSSION OF MR. E. G. HILLER'S PAPER ON "THE WORKING OF THE BOILER EXPLOSIONS ACTS, 1882 AND 1890."*

Mr. HENRY LAWRENCE said that, notwithstanding the large increase in the number of boilers now working, there was a large decrease in the number of explosions. He thought that this had been brought about by improved design, material, workmanship and machinery used in the manufacture of boilers. Some 44 years ago when he came to the north of England, he found among the collieries and works that very few boilers other than plain cylindrical ones were in use. At that time, in London and the outskirts, the most economical boiler that they could get was used at waterworks on account of the high price of coal—that was the Cornish boiler with one flue, in which the combustion was so slow that they could put their hands upon the furnace-doors. And at some of the large waterworks, fuel (coke-breeze mixed with duff-coal) was burnt that men would not look at nowadays.

The plain cylindrical boiler—then in use—was badly designed. The material was not suitable to put into any boiler. "Ship-plates" were used, and he thought that he would be right in saying that some of them

* *Trans. Inst. M.E.*, vol. xvii., page 19.

were little better than cast iron. Low Moor iron was used along the bottom of the boiler for a certain length over the fire, and he contended that coupling such a class of iron with ship-plates was ruinous to the boiler itself.

The fire-bars were, as was usual in those days, about 2½ inches thick, with an air-space of 1½ inches. They were cleaned by knocking at the projecting end of the bar, and, as a consequence, not more than half the coal was burned under the boiler, and the remainder was wheeled out on to the top of the waste-heap. The enormous heat caused deposits to accumulate over that part of the boiler where the evaporation was greatest, the plates came down, and boiler-smiths were continually repairing them. Repairs were generally very roughly made, and little was thought of putting in a "stop-rivet," as it was called.

Seam-rips were produced in plain cylindrical boilers, because they were always supported on their seating by means of a series of cast-iron brackets; later the boilers were increased in length, and they were hung from arched-brackets, so as to be entirely suspended. As the boilers were not covered, the enormous heat passing under the boilers and the expansion at the bottom caused the boilers to lift up their ends: as the boilers were made in rings, there was a tendency to open the lower part of the ring and its rivets, and hence seam-rips were commenced.

The material was so bad that, after a plate was flanged and nearly finished, it would be condemned as rotten. They had no such material as mild steel, which can be flanged round the fire-box by hydraulic power in one operation.

He considered that the workmen of the present day were more competent than those of 40 years ago, and boiler-makers generally were a different class of men from what they used to be. At the present day, in boiler-shops the tubes were welded, and then flanged, entirely by machinery, in such a way that nothing more accurate could be made.

The improved design, and improved workmanship, of boilers of the present day had reduced the number of explosions; and he was of opinion that the Boiler Explosions Acts had been decidedly beneficial. He knew that the Board of Trade considered that everything liable to burst was a steam-boiler. He himself was unfortunate enough to have a globe valve, placed underground some 70 or 80 feet from the shaft-bottom, which passed the steam to an underground engine: the workmen had been making some repairs to a steam-pipe, and instead of the engineman opening the cocks at the steam-engine he opened the valve suddenly and let the water pass out at the tap. When steam was turned

on, the valve burst, and a man was killed. An enquiry was held by an inspector from the Board of Trade and the valve was brought to his works. (There was some doubt as to whether the valve had been made at their works or not.) The valve in question was broken open; it was found that it was of proper thickness; the Board of Trade published an elaborate report, and there had been as much money spent over the case as though it had been a boiler-explosion.

In looking over the paper he found that Prof. Louis, in the discussion, "asked whether Mr. Hiller could give the members any idea of the average increase in steam-pressure during the years comprised in Table II. He took it as undoubted that from 1866 to 1897, the average steam-pressure had been steadily increasing, and if they could get this information so as to form a base-line from which the number of accidents could be tabulated, it might, he thought, be shown that an increase in steam-pressure was accompanied by an increase in safety."* He (Mr. Lawrence) agreed with that statement, as he did not think it could be proved that an increase of pressure had caused any increase in the number of boiler explosions. It appeared to him, that if a boiler had to withstand a pressure of 200 pounds per square inch, whereas only 50 pounds was formerly required, more attention would be given to its manufacture by the boiler-maker.

Mr. A. L. Steavenson (Durham) said that the subject of the paper was the working of the Boiler Explosions Acts. Nevertheless, the paper, and the discussion, seemed to have been devoted to boiler explosions, and he thought that it would be interesting if the members would each give their experience of the working of the Acts. He had a certain boiler heated by the waste-gases from coke-ovens, and, as the heat was very great at week-ends, the boiler "primed"—water got into a steam-pipe, and the pipe was cracked longitudinally. He reported the matter to the Board of Trade, whereupon several of their inspectors came to the colliery and made numerous measurements, and finally the pipe was smashed to see whether it was made of suitable material and thickness. After a long delay, he received a report on the explosion of a steam-pipe at Tursdale colliery.

Mr. T. E. Forster (Newcastle-upon-Tyne) said that probably few engineers nowadays had boiler explosions, but if they had a blown joint in a steam-pipe, according to the letter of the Boiler Explosions Acts, it was necessary to report it to the Board of Trade. He had had one

* *Trans. Inst. M.E.*, vol. xvii., page 48.

experience of a Board-of-Trade enquiry, and he hoped that it would be the last as it was the first. It was very much better when inquiries as to all accidents at collieries were made by inspectors of mines under the Home Secretary.

Mr. HENRY LAWRENCE said that he would recommend every steam-user to cover the boilers, and to take as much trouble to keep them clean and under cover as they would with a steam-engine.

Mr. J. F. L. CROSLAND (Manchester) wrote that he had always entertained the opinion that the Boiler Explosions Act of 1882 was sufficient, if properly enforced, to extinguish preventable boiler explosions. His impression on this point was so strong that in 1889—at which time he might observe that no less than 336 enquiries into boiler explosions had been made under the Boiler Explosions Act and in only one solitary instance out of all that number was a formal investigation held, and then no fine or charge was made upon the offender—he drew the attention of Mr. Summers (M.P. for Huddersfield) to the matter, and induced him to ask in the House of Parliament why the penal clauses had hitherto not been properly enforced, to which Sir Michael Hicks Beach replied that "he was carefully considering whether in the public interest the Boiler Explosions Act could not be more stringently enforced in future." In consequence of that enquiry, during the following year, up to April 17th, 1891, no less than 31 formal investigations were held, and fines of various amounts from £10 to £80 were inflicted. Since that date, formal investigations have regularly taken place, and fines of small amounts have been inflicted. Still, not only the number, but the serious character of boiler explosions had been reduced, as pointed out in the paper under discussion. In fact, the result had been so satisfactory that he felt perfectly convinced that if the fines were made more severe and the results published, preventable boiler explosions would become a thing of the past, or, to repeat Sir Michael Hicks Beach's remark upon the subject, that "publicity and penalties would do more good than anything that Parliament could do."

Mr. E. G. HILLER (Manchester), replying to the discussion, wrote that he observed that several gentlemen called attention to the fact that they had had accidents to steam-pipes which had been investigated by the Board of Trade under the Boiler Explosions Acts. Although these investigations no doubt would cause them some personal inconvenience, on the other hand, the information obtained from investigations of this kind had proved to be of considerable value; and if the lessons

taught by the accidents received proper consideration the number of such accidents would be considerably reduced in the future. While, therefore, he considered it desirable that steam-pipe accidents should be investigated, he thought it was undesirable that they should be classed as boiler explosions. He agreed with Mr. Lawrence's remarks recommending steam-users to cover boilers, and to take as much trouble to keep them clean and under cover as they would with a steam-engine. Very frequently, however, boilers at collieries were not enclosed in boiler-houses, and under such circumstances, owing to the exposure to weather, they sometimes became damp, which might lead to external wasting of the plates beneath. To avoid the risk of explosion from this cause, periodical baring of the covering was necessary.

DISCUSSION OF MESSRS. HEISE AND THIEM'S "EXPERIMENTS ON THE IGNITION OF FIRE-DAMP AND COAL-DUST BY MEANS OF ELECTRICITY."*

Mr. A. L. Steavenson (Durham) thought that this paper showed very clearly that the conditions under which it was safe to employ electricity in coal-mines were rare. In the summary of precautions to be observed, it was pointed out that the experiments were not made with the object, nor were they capable, of formulating a definite opinion as to the applicability of electricity in fiery mines; and it was further stated that "the sum of the results obtained shows that in general the amount of electrical energy which is capable under certain circumstances of igniting fire-damp need only be extremely small."† It appeared to him (Mr. Steavenson) that whether it was extremely small or extremely great, it was shown to be equally dangerous. The individual results of the experiments upon incandescent lamps were summarized in the paper as follows:—

(a)	2	candle-power lamps	for	6	volts and	0·80	ampère	unsafe.
(b)	10	,,	,,	65	,,	0·46	,,	safe.
(c)	16	,,	,,	65	,,	0·77	,,	unsafe.
(d)	16	,,	,,	100	,,	0·50	,,	safe.
(e)	16	,,	,,	150	,,	0·33	,,	safe.
(f)	25	,,	,,	110	,,	0·73	,,	unsafe.
(g)	25	,,	,,	150	,,	0·58	,,	safe.
(h)	25	,,	,,	220	,,	0·38	,,	safe.
(j)	35	,,	,,	100	,,	1·00	,,	unsafe.
(k)	50	,,	,,	100	,,	1·50	,,	unsafe.
(l)	100	,,	,,	100	,,	3·00	,,	unsafe.‡

* *Trans. Inst. M.E.*, vol. xvii., page 88. † *Ibid.*, page 114. ‡ *Ibid.*, page 96.

If the margin between safety and danger was so small that, although they could use a 10 candle-power lamp for 65 volts and consider themselves safe, while with a 16 candle-power for 65 volts they were unsafe, he thought it proved that it was neither safe nor pleasant to introduce electricity into the fiery atmosphere of a mine.

DISCUSSION OF MR. D. MURGUE'S PAPER ON "THE MURGUE RECORDING VOLUMETRIC ANEMOMETER.*

Mr. BRYAN DONKIN (London) wrote that he had read with pleasure this paper, describing a very ingenious arrangement for recording the air-pressures in certain parts of a fan or in a mine in restricted air-ways; and coming from so distinguished a mining-engineer, it demanded careful attention. It seemed to be a most useful and instructive apparatus for studying vacuums or pressures in mines on a time basis, but a better opinion could be given if one had actually seen the instrument at work. He suggested that a committee should be appointed for experimenting with one (to be obtained from France), that it should be tested at one or two British mines for some months, and that the committee should report to the members. It could be no doubt made applicable to other fans than the Rateau fan and in restricted air-ways. No doubt a time-record on paper of air-pressures in mines was very important, and such an instrument, based on the Pitot-tube system properly applied, he thought, was well worth testing, and the results should be followed closely by mining-engineers.

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* *Trans. Inst. M.E.*, vol. xvii., page 261.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE ODDFELLOWS' HALL, KILMARNOCK, DECEMBER 9TH, 1899.

MR. DAVID SMITH IN THE CHAIR

The minutes of the last General Meeting were read and confirmed.

There being no further discussion on Mr. George L. Kerr's paper on "Timbering and Supporting Underground Workings," and Mr. W. D. L. Hardie's paper on "Machine-mining and Pick-mining Compared," the discussion of these papers was closed, and a hearty vote of thanks was given to the respective authors.

Mr. Thomas H. Mottram's paper on "Explosions of Fire-damp and Coal-dust in the West of Scotland" was read as follows :—

EXPLOSIONS OF FIRE-DAMP AND COAL-DUST IN THE WEST OF SCOTLAND.

By THOMAS H. MOTTRAM, H.M. Inspector of Mines.

Happily of recent years, in Scotland, we have been spared large explosions of fire-damp, such as have from time to time visited the neighbouring coal-fields of England and Wales.

The West of Scotland mines-inspection district, however, has not been by any means free from minor disasters, if we bear in mind the Quarter (Stirlingshire) explosion in 1895, and the Drumpeller (Lanarkshire) and Drumley (Ayrshire) explosions in 1898. But although these in the aggregate do not, so far as the number of deaths is concerned, sum up to anything like the somewhat recent explosions in 1896 at Micklefield in Yorkshire and Tylorstown in South Wales, yet, taking the last 4 years, the separate fatal explosions and separate non-fatal explosions greatly outnumber those in most of the other mines-inspection districts; and whilst the number of separate fatal explosions does not quite come up to the number for the South Wales mines-inspection district—in which district it should be borne in mind that more than double the number of persons are employed—we figure considerably higher in the non-fatal accidents, the number of the latter being in the last 4 years: West of Scotland, 166; and South Wales, 123.

The separate fatal explosions during the same period were:—West of Scotland, 14; and South Wales, 17.

Table I. shows the fatal and non-fatal explosions which have occurred in the West of Scotland mines-inspection district during the past 10 years. The writer, for want of figures, has been unable to compare these with those both fatal and non-fatal in other parts of the kingdom for a longer period than 4 years.* Tables II. and III. show comparisons between the different mines-inspection districts in the United Kingdom.

The persons employed underground in the United Kingdom during the past 4 years numbered on the average 561,773; of these $\frac{1}{17}$th or thereabouts, namely, 32,231 were employed in the West of Scotland. The

* *Trans. Inst. M.E.*, vol. xi., page 651; vol. xiii., page 675; vol. xv., page 619; and vol. xvii., page .

separate fatal accidents during the same period in the West of Scotland were much out of proportion, for they numbered no less than 14; whereas, reckoning on the basis of the persons employed, there ought to have been only 4. The total number of deaths for the United Kingdom was 274; $\frac{1}{17}$ of this is about 16, whereas the actual number was 35, or more than double the proportion reckoned on the basis of the number of persons employed. Treating the separate non-fatal accidents in the same way, the difference becomes still more remarkable: the total number was 559, and $\frac{1}{17}$th of this is about 33, whereas the actual number was no less than 166, or five times the calculated proportion.

TABLE I.—SUMMARY OF EXPLOSIONS OF FIRE-DAMP AND COAL-DUST IN THE WEST OF SCOTLAND MINES-INSPECTION DISTRICT FROM 1889 TO 1898.

Years.	Average No. of Persons Employed below Ground.	Fatal Accidents. No.	Fatal Accidents. Deaths.	Non-fatal Accidents. No.	Non-fatal Accidents. No. of Persons Injured, including those Injured in Fatal Accidents.
1889 ...	29,202	4	5	35	54
1890 ...		5	5	39	56
1891 ...		1	1	25	30
1892 ...		2	2	42	70
1893 ...		2	3	31	46
		— 14	— 16	— 172	256
1894 ...	32,276	5	5	21	34
1895 ...		2	14*	47	66
1896 ...		5	5	39	58
1897 ...		2	2	39	55
1898 ..		5	14†	41	71
		— 19	— 40	— 187	— 284

* Including Quarter colliery explosion, 13 deaths.
† Including Drumley colliery explosion, 7 deaths.

TABLE II.—SUMMARY OF FATAL EXPLOSIONS OF FIRE-DAMP AND COAL-DUST IN THE SEVERAL MINES-INSPECTION DISTRICTS FROM 1895 TO 1898.

Years.	East Scotland.	West Scotland.	Newcastle-upon-Tyne.	Durham.	Yorkshire and Lincolnshire.	Manchester.	Ireland.	Liverpool.	Midland.	North Staffordshire.	South Staffordshire.	South-Western.	South Wales.	Totals.
ACCIDENTS :—														
1895 ...	2	2	1	0	1	1	0	1	1	0	2	2	7	20
1896 ...	3	5	3	1	2	0	0	0	0	0	3	0	8	25
1897 ...	3	2	0	0	1	0	0	0	1	0	2	1	2	12
1898 ...	1	5	1	1	2	0	1	0	0	0	1	0	0	12
Totals ...	9	14	5	2	6	1	1	1	2	0	8	3	17	69
DEATHS :—														
1895 ...	2	14	1	0	2	5	0	1	7	0	4	9	10	55
1896 ...	4	5	4	20	64*	0	0	0	0	0	3	0	73†	173
1897 ...	4	2	0	0	3	0	0	0	1	0	2	1	6	19
1898	3	14	1	2	3	0	3	0	0	0	1	0	0	27
Totals ...	13	35	6	22	72	5	3	1	8	0	10	10	89	274

* Including Micklefield colliery explosion, 63 deaths.
† Including Tylorstown colliery explosion, 57 deaths.

TABLE III.—SUMMARY OF NON-FATAL EXPLOSIONS OF FIRE-DAMP AND COAL-DUST IN THE SEVERAL MINES-INSPECTION DISTRICTS FROM 1895 TO 1898.

Years.	East Scotland.	West Scotland.	Newcastle-upon-Tyne.	Durham.	Yorkshire and Lincolnshire.	Manchester.	Ireland.	Liverpool.	Midland.	North Staffordshire.	South Staffordshire.	South-Western.	South Wales.	Totals.
ACCIDENTS:—														
1895 ...	29	47	5	4	6	2	0	3	3	4	10	2	29	144
1896 ...	25	39	4	7	3	1	1	2	4	3	9	2	29	129
1897 ...	28	39	13	2	8	0	0	1	4	2	6	0	33	136
1898 ...	28	41	10	7	7	2	1	5	4	2	7	4	32	150
Totals ...	110	166	32	20	24	5	2	11	15	11	32	8	123	559
INJURED:—														
1895 ...	43	66	7	6	9	3	0	9	5	7	15	2	43	215
1896 ...	30	58	8	7	8	1	1	2	2	4	11	3	53	188
1897 ...	39	55	15	2	11	0	0	3	9	2	7	0	42	185
1898 ...	35	71	17	9	11	2	1	6	4	2	16	5	44	223
Totals ...	147	250	47	24	39	6	2	20	20	15	49	10	182	811

Members who have read the report by Mr. Ronaldson for 1898, wherein he stated that "out of 27 lives lost in the United Kingdom no fewer than 14 were lost in the West of Scotland, while year by year there are more non-fatal explosions in this district than in any other," will not be surprised at the writer's figures, although others, who have been disposed to consider the West of Scotland for the most part as non-fiery will probably be unprepared for so unfavourable a comparison.

Reverting to Table I. which deals with the West of Scotland mines-inspection district alone, it will be seen that the number of explosions for the last 5 years compares unfavourably with those of the previous 5 years, no diminution being shown, but, on the contrary, an increase greater than the larger number of persons employed warrants. For instance :—

Period.	Average Number of Persons Employed Below Ground.	No. of Fatal Accidents.	No. of Non-fatal Accidents.	No. of Deaths.	No. of Persons Injured.
1889 to 1893	... 29,202	... 14	... 172	... 16	... 256
1894 to 1898	... 32,276	... 19	... 187	... 40	... 284

In the reports for the West of Scotland mines-inspection district for 1895-98 the explosions during those years are classified according to cause as follows :—

Cause.	No. of Fatal Accidents.	No. of Deaths.	No. of Non-fatal Accidents.	No. of Persons Injured.
Naked lights ...	9 ..	15* ...	162 ...	230
Safety-lamps ...	2 ...	14† ...	1 ...	4
Shot-firing ...	2 ..	5 ...	3 ...	12
Miscellaneous ..	1 ...	1 ...	0 ...	4

* Including Drumley (Ayrshire) colliery explosion, 7 deaths.
† Including Quarter (Stirlingshire) colliery explosion, 13 deaths.

It is apparent from these figures that most of the numerous non-fatal explosions occurred in naked-light pits, while others have been caused by blasting in proximity to fire-damp. The Drumpeller colliery explosion was also caused by blasting, although it was evidently merely a case of coal-dust ignited by a powder-shot. A few of the instances as published in the reports for the West of Scotland mines-inspection district showing the manner in which some accidents—both fatal and non-fatal—have occurred, are given as follows :—(1) Through entering workings 7 hours after fireman's examination ; (2) on piercing a seam of coal in a sinking pit ; (3) miners assisting fireman to remove fire-damp ; (4) inspecting with naked lights instead of safety-lamps ; (5) allowing workers to enter before gas was cleared away ; (6) working in an unventilated gallery ; (7) sudden outburst of gas ; (8) entering disused workings ; (9) working along the edge of old waste ; and (10) ignition of fire-damp on entering after fireman's examination.

Like some of the above, many other accidents occurred through contraventions of the General and Special Rules, and it might therefore be said that the remedy does not altogether lie in formulating more rules and regulations, when there is already considerable difficulty in getting those already in vogue carried out. At the same time, it should be borne in mind that when so many explosions occurred through contraventions, they must be termed preventible accidents.

Twenty years ago the late Mr. Alexander, when giving evidence before the Royal Commission on Accidents in Mines, seemed to think "that with a very few exceptions in a general way a large proportion of the accidents by explosions might be avoided by sufficient supervision, or sufficient examination, or by the introduction of safety-lamps." What Mr. Alexander thought 20 years ago the writer ventures to say most engineers think holds good to-day.

Are the fireman's examinations of the working-places, upon which so much depends, in all cases arranged to be made in a systematic manner? General Rule 4 and Special Rule 35 provide for a statutory examination of every part of the mine which is to be traversed by workers during the shift, not more than 2 hours immediately before the commencement of each shift—a very definite and excellent provision in itself, but what about the inspection during the shifts? As no fixed hour is stated for this, is it always done when it is likely to be of most use? A shift means 8 to 10 hours, and provided the inspection is made during even the last half-hour who can say that the General and Special Rules have been contravened? It is not here alleged that it is customary to put off this later

examination until the last hour or so, but an arrangement in all mines preventing the hour of examination being delayed would be helpful; it would be better still if the practice adopted in some pits of having two inspections by the fireman during the shift could be managed. And in these inspections during the shift, as in the case of the morning inspection, the safety-lamp should be always carried, because although open lights are in use, there are holes and breaks in the roof in most workings where fire-damp might be accumulated, and these accumulations, for want of timely discovery by proper means, might otherwise be ignited, to the danger of those present in the mine.

Then, the more a fireman can be confined to statutory duties the better, and his district should not be too large for him to thoroughly and carefully examine within the 2 hours' limit. Moreover, he should be impressed with the necessity that there is for not only reporting the finding of the smallest quantity of inflammable gas to the overman, but that it is his imperative duty to record the same in the report-book; and that, no matter how small the accumulation, it should be thoroughly cleared before the workers are allowed to enter; also that the clearing away of fire-damp should be by such means as will also keep it from accumulating afresh. Should this not be done—for instance, if the somewhat antiquated and dangerous method of "waffing" is practised, it is not unlikely, but extremely probable, that in a short time afterwards fire-damp will again accumulate. It is also desirable that a fireman should carry two safety-lamps when making his morning inspection, as cases have occurred where, through his getting in the dark, the use of a match for rekindling has resulted in fatal consequences.

An important detail is the conduction of a current of air into all places where men are required to work—such as in trial-headings or close places, proving "steps," and in workings alongside old wastes. In all places ventilated by bratticing or other means, these should be systematically extended and maintained as the faces advance. There should be a more general use, too, of hurdle-screens, not only where fire-damp has been seen, but also in those places where it might be expected to appear. In all such places, as those above-mentioned, explosions continue to happen from time to time.

A regular inspection of all air-courses and a periodical report upon their condition, as is done in some pits, is desirable, as also is the maintenance of tramways in air-courses, as far as possible, so that surplus dirt from falls can the more easily be cleared away, leaving the area of the air-course intact. The measurement of the air-current not only at

the entrance to a section or ventilating district, but at one or more points in the working-places, by an official other than the person appointed to travel along the air-courses, is an excellent means of checking defects, and thereby providing a remedy.

Then, again, what might be termed the mixed use of lights is fraught with danger ; as, for instance, in the case of a miner working at the coal-face with a naked light and a safety-lamp hanging at the road-head, with which he is expected to examine the place after a shot or on returning after being absent from his place. This precaution might or might not be the means of preventing an accident; but at the same time if a place is liable to produce fire-damp, the open light should be withdrawn to guard against accident. It is presumed that one of the reasons for giving the open light at the coal-face may be the necessity that would follow under General Rule 8, that when it is necessary to work the coal in any part of a ventilating-district with safety-lamps it is not allowable to work the coal with naked lights in another part of the same ventilating-district situated between the place where such safety-lamps are being used and the return air-course. And another reason is that an open-light pit is not as a rule provided with enough safety-lamps to give effect to this rule, still the event of having naked lights in such a place is not conducive to the reduction of explosions.

The writer does not make these observations without some diffidence before members, who, if they thought proper, could boast of being connected with collieries second to none in the kingdom, not only as regards appliances of the most modern type but in the enforcement of rules in advance of those laid down by the Coal-Mines Regulation Acts. The object of the writer, however, is to promote a discussion of the question of fire-damp explosions in the open-light pits of the West of Scotland mines-inspection district, a discussion which may result in saving of life. It is no new matter, and is yearly brought to the notice of the members in the annual reports of Mr. Ronaldson, H.M. inspector of mines for the district. In his report for last year, he said:—"I am sorry to have to state that there still continues in my district a reckless disregard of the regulations intended to prevent explosions as well as other accidents." Then as to non-fatal accidents, Mr. Ronaldson stated that "While many of these with naked lights in use could not be easily prevented, a very large proportion of them would not occur with ordinary precaution and a proper regard to the regulations."

How is this disregard of regulations to be remedied, and how are the

mines in the West of Scotland to be extricated from the unenviable position which they occupied as regards explosions as compared with the rest of the United Kingdom? Is there not, here and there, want of knowledge of the rules affecting the duties of under-officials with regard to fire-damp? Could not more be done to bring to the notice of firemen and others the necessity for the thorough observance of the rules? and should not a thorough knowledge of the rules be obligatory before firemen are appointed to take up statutory duties? If nothing further can be done, mining engineers must admit that the only means of improvement lies in the abolition of open lights in all mines known to be giving off inflammable gas; or in the still more drastic remedy of abolishing the use of open lights altogether.

The matter is, no doubt, fraught with some difficulty, but the writer is convinced that it is not insurmountable. Arguments have been adduced against the use of safety-lamps to the effect that a more general application of their use might probably reduce explosions: but that, on the other hand, accidents by falls of roof, etc., would increase, the miner having been deprived of the superior illumination afforded by the open light. The writer noticed that at the last annual meeting of the National Association of Colliery Managers, Mr. John Knowles, the president, was reported to have stated that this argument had become an exploded theory; and at a previous discussion at this institute Mr. Ronaldson expressed similar views, no doubt based on his lengthy experience.

If the present-day safety-lamp did not afford a sufficient light to enable workers to keep themselves safe from falls of roof and sides, the argument referred to would be a sound one, but probably no one accustomed to the use of a modern safety-lamp will go the length of saying that the light of a safety-lamp is insufficient for that purpose.

If falls of roof, etc., in the West of Scotland mines-inspection district, in which so many open lights were in use, were fewer in proportion than in other districts where the roofs were somewhat similar and safety-lamps were more generally used, then the argument against reducing the number of open lights would be worthy of serious consideration, as it would not be desirable to decrease one risk at the expense of another.

The members have the important testimony of our President, Mr. James Forgie, that through the introduction of safety-lamps in some of his pits "numerous small explosions of fire-damp and fires in the workings are now a thing of the past,"* but the writer thinks that Mr. Forgie did

* *Trans. Inst. M.E.*, vol. xvi., page 433.

not go the length of saying that their introduction was the advent of an increased number of falls from roof and sides.

In conclusion, it seems to the writer that the reason why explosions are more numerous in the West of Scotland mines-inspection district than in the other districts of the United Kingdom must be :—

(1) That either in what are sometimes called non-fiery mines there is more fire-damp than is generally supposed, or

(2) That the use of safety-lamps is not so prevalent as is the case in similar mines elsewhere, and therefore the use of so many open lights, coupled with the unfortunate contraventions of rules, is responsible for a large share of our explosions.

For his own part, though he would like to see a more extended use of safety-lamps, which experience had shown to be an excellent preventive, the writer thought that the next best remedy would be an improved system of inspection by underground officials, and a still more rigorous enforcement of the present rules and regulations, and he believed that the effect would show itself not only in a diminution of the number of explosions of fire-damp but also in a reduction of the number of accidents by falls.

Mr. ROBERT W. DRON read the following paper on "The Probable Duration of the Scottish Coal-fields":—

THE PROBABLE DURATION OF THE SCOTTISH COAL-FIELDS.

By ROBERT W. DRON.

The object of the present investigation is to ascertain, not only the total quantity of available coal in Scotland, but how much of this coal is found in seams of such a thickness and lying at such a depth that they can be worked without an increased cost per ton. It will also be important to note which counties contain the largest reserve-supplies in proportion to their present output of coal.

In Table I. details are given of the total quantity of coal which originally existed in each county and district, and the deduction for coal already worked is made later. A seam of coal 12 inches thick and 1 square mile in area contains rather more than 900,000 tons, but from this figure a sufficient deduction must be made for faults, barriers and coal lost in working, and for this reason all the estimates have been made on the basis of 600,000 tons per foot thick per square mile. Seams, actually known to be workable, are only included as "proven" coal. Seams less than 2 feet thick and all coal-seams of the Limestone Measures lying below the Millstone Grit and the Upper Coal-measures are classed as "unproven."

It is not proposed to give a description of each separate district, but a few remarks are necessary to show the reasons for the various estimates of area and thickness in each county.

Ayrshire.—The total thickness of coal in the Upper Coal-measures, from the McNaught coal-seam of Kilmarnock to the Main coal-seam of Kilwinning, amounts to 38 feet, and in the corresponding section at Old Cumnock and New Cumnock there is a thickness of from 18 feet to 50 feet. In no part of the district has the maximum thickness been found at any single colliery, and the thickness of proven coal in each area has been found by taking a fair average of the thicknesses of the seams actually worked at the various collieries. In the Kilwinning and

TABLE I.—SHOWING THE TOTAL QUANTITY OF AVAILABLE COAL IN SCOTLAND.

Name of County and District.	Upper Coal-measures.						Carboniferous Limestone.												Totals of Available Coal.	
							Surface-exposure.													
	Coal-seams being worked.			Thin and uncertain Coal-seams, etc.			Coal-seams being worked.			Thin and uncertain Coal-seams, etc.			Coal-seams lying below the Millstone Grit			Coal-seams lying below the Upper Coal-measures.				
	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Proven.	Reserves.
	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Tons.	Tons.
AYRSHIRE—																				
Kilwinning	26·00	16	230,400,000	21·00	8	115,200,000	6·53	4	15,672,000	—	—	—	—	—	—	24·00	4	57,600,000	216,072,000	172,800,000
Kilmarnock	15·83	15	142,470,000	15·83	5	47,490,000	—	—	—	—	—	—	—	—	—	Probably unworkable..			142,470,000	47,490,000
Galston	3·92	24	56,448,000	3·92	6	14,112,000	—	—	—	—	—	—	—	—	—	Do.	do. ..		56,448,000	14,112,000
Dundonald	—	—	—	10·34	3	18,612,000	—	—	—	—	—	—	—	—	—	Do.	do. ..		—	18,612,000
Adamhill	—	—	—	19·80	3	35,640,000	—	—	—	—	—	—	—	—	—	Do.	do ..		—	35,640,000
Annbank ..	20·00	5	60,000,000	20·00	4	48,000,000	—	—	—	—	—	—	—	—	—	Do.	do. ..		60,000,000	48,000,000
Troon and Ayr	—	—	—	9·90	3	17,820,000	—	—	—	—	—	—	—	—	—	Do.	do		—	17,820,000
Lugar and Cumnock ..	40·62	12	292,464,000	40·62	2	48,744,000	—	—	—	—	—	—	—	—	—	41·80	5	125,400,000	292,464,000	174,144,000
Sorn and Weitshaw ..	1·79	10	10,740,000	1·79	2	2,148,000	5·22	7	21,924,000	5·22	2	6,264,000	—	—	—	—	—	—	32,664,000	8,412,000
Muirkirk	—	—	—	—	—	—	5·60	25	87,000,000	5·80	5	17,400,000	3·26	20	39,120,000	—	—	—	87,000,000	56,520,000
Aird's Moss	—	—	—	—	—	—	—	—	—	—	—	—	1·75	20	21,000,000	—			—	21,000,000
New Cumnock . ..	13·60	20	163,200,000	13·60	6	48,960,000			—	—	—	—	—	—	—	13·60	6	48,960,000	163,200,000	97,920,000
Guelt and Gasswater ..		—	—	—	—	—	—	—		1·75	12	12,600,000	—	—	—	—	—	—	—	12,600,000
Glaisnock	—	—	—	—	—	—	—	—	—	—	—	—	7·30	10	43,800,000	—	—	—	—	43,800,000
Dalmellington, North of	—	—	—	20·60	5	61,800,000	—	—	—	—	—	—	—	—	—	20·60	6	74,160,000	—	135,960,000
Dalmellington & Patna	13·49	25	202,350,000	13·49	8	64,752,000	1·89	10	11,340,000	1·89	1	1,134,000	5·64	10	33,810,000	13·49	6	48,564,000	213,690,000	148,280,000
Girvan	—	—	—	—	—	—	1·79	30	32,220,000	1·79	5	5,370,000	—	—	—	—	—	—	32,220,000	5,370,000
Dalry	—	—	—	—	—	—	12·12	4	29,088,000	—	—	—	—	—	—	—	—	—	29,088,000	—
Monkredding, etc. ..	—	—	—	—	—	—	—	—	—	6·81	2	8,172,000	—	—	—	—				8,172,000
DUMBARTONSHIRE—																				
Kirkintilloch	—	—	—	—	—	—	5·36	8	25,728,000	5·36	2	6,432,000	—	—		—	—	—	25,728,000	6,432,000
Nethercroy, etc.	—	—	—	—	—	—	8·71	4	20,904,000	8·71	2	10,452,000	—	—	—	—	—	—	20,904,000	10,452,000
Cumbernauld	—	—	—	—	—	—	—	—	—	8·69	3	15,642,000	6·66	3	11,988,000	—		—	—	27,630,000
Kilpatrick, etc .. .	—	—	—	—	—	—	6·40	1½	5,760,000	—	—	—	—	—	—	—	—	—	5,760,000	—
Garscube	—	—	—	—	—	—	3·50	6	12,600,000	3·50	2	4,200,000	—	—	—	—	—		12,600,000	4,200,000
LANARKSHIRE—																				
Clyde Basin, Upper Seams	62·30	20	747,600,000	62·30	2	74,760,000	—	—	—	—	—	—	—	—		62·30	2	74,760,000	747,600,000	149,520,000
Do., Lower Seams ..	62·30	5	186,900,000	—	—	—	—	—	—	—	—	—	—	—	—	—	—		186,900,000	—
Millerston to Airdrie ..	18·50	8	88,800,000	18·50	2	22,200,000	—			—	—	—	—	—	—	18·50	1	11,100,000	88,800,000	33,300,000
New Monkland	20·50	9	110,700,000	20·50	2	24,600,000		—	—	—	—	—	—	—	—	20·50	3	36,900,000	110,700,000	61,500,000
Chapelhall and Harthill	51·08	12	367,776,000	51·08	3	91,944,000	—	—	—	—	—	—	—	—	—	51·08	6	183,888,000	367,776,000	275,832,000
Newmains	9·10	14	76,440,000	9·10	1	5,460,000	—	—	—	—	—	—	—	—	—	9·10	8	43,680,000	76,440,000	49,140,000
Wilsonton	—	—	—	—	—	—	8·90	10	53,400,000	—	—	—	15·06	8	72,288,000	—	—	—	53,400,000	72,288,000
Carluke	—	—	—	—	—	—	3·82	8	18,336,000	3·82	2	4,584,000	—	—	—	—	—	—	18,336,000	4,584,000
Auchenheath	—	—	—	—	—	—	5·30	2	6,360,000	—	—	—	—	—	—	—	—	—	6,360,000	—
Avondale	12·80	4½	34,560,000	12·80	3	23,040,000	—		—	—	—	—	—	—	—	12·80	probably unworkable		34,560,000	23,040,000
East Kilbride and Quarter		—	—	—	—	—	—	—		35·28	2	42,336,000	—	—	—	—	—	—	—	42,336,000

TABLE 1.—*Continued.*

Name of County and District.	Upper Coal-measures.						Carboniferous Limestone.												Totals of Available Coal.	
	Coal-seams being worked.			Thin and uncertain Coal-seams, etc.			Surface-exposure. Coal-seams being worked.			Surface-exposure. Thin and uncertain Coal-seams, etc.			Coal-seams lying below the Millstone Grit.			Coal-seams lying below the Upper Coal-measures.				
	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Proven.	Reserves.
	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Tons.	Tons.
LANARKSHIRE—*Continued.*																				
Garnkirk	—	—	—	—	—	—	—	—	—	—	—	—	19·93	4	47,832,000	—	—	—	—	47,832,000
Cadder	—	—	—	—	—	—	8·40	3	15,120,000	8·40	3	15,120,000	—	—	—	—	—	—	15,120,000	15,120,000
Glasgow	—	—	—	—	—	—	13·21	5	39,630,000	—	—	—	6·68	4	16,032,000	—	—	—	39,630,000	16,032,000
Douglas	2·40	20	28,800,000	2·40	8	11,520,000	—	—	—	—	—	—	—	—	—	2·40	10	14,400,000	28,800,000	25,920,000
Coalburn	—	—	—	—	—	—	4·30	20	51,600,000	4·30	5	12,900,000	—	—	—	—	—	—	51,600,000	12,900,000
Rigside	—	—	—	—	—	—	1·50	40	36,000,000	1·50	10	9,000,000	—	—	—	—	—	—	36,000,000	9,000,000
Brokencross Muir ..	—	—	—	—	—	—	3·20	6	11,520,900	3·20	4	7,680,000	—	—	—	—	—	—	11,520,000	7,680,000
Glespin	1·80	25	27,000,000	1·80	10	10,800,000	—	—	—	2·00	10	12,000,000	—	—	—	2·75	10	16,500,000	27,000,000	39,300,000
RENFREWSHIRE—																				
Paisley	—	—	—	—	—	—	—	—	—	14·00	3	25,200,000	—	—	—	—	—	—	—	25,200,000
Linwood	—	—	—	—	—	—	6·28	6	22,608,000	10·08	3	18,144,000	—	—	—	—	—		22,608,000	18,144,000
Renfrew	—	—	—	—	—	—	—	—	—	3·36	6	12,096,000	—	—	—	—	—		—	12,096,000
Quarrleton	—	—	—	—	—	—	0·25	92	13,800,000	—	—	—	—	—	—	—	—	—	13,800,000	—
Howwood	—	—	—	—		—	0·86	3	1,548,000	0·86	2	1,032,000		—			—		1,548,000	1,032,000
Pollock, etc.	—	—	—	—	—	—	12·80	5	38,400,000	12·80	3	23,040,000	1·39	8	6,672,000		—		38,400,000	30,712,000
Lochwinnoch	—	—	—	—	—		2·80	4	6,720,000	—	—	—	—	—	—		—		6,720,000	—
Caldwell	—	—		—	—		0·40	4	960,000	—	—	—	—	—	—	—	—	—	960,000	—
STIRLINGSHIRE—																				
Kilsyth	—	—	—	—	—	—	7·14	8	34,272,000	7·14	2	8,568,000	—	—	—	—	—	—	34,272,000	8,568,000
Denny	1·80	11	11,880,000	1·80	2	2,160,000	—	—	—	3·46	3	6,228,000	—	—	—	—	—	—	11,880,000	8,388,000
Bannockburn, etc. ..	—	—	—	—	—	—	15·84	6	57,024,000	15·84	3	28,512,000	—	—	—	—	—	—	57,024,000	28,512,000
Carron	12·50	6	45,000,000	12·50	3	22,500,000	—	—	—	—	—	—	—	—	—	12·50	3	22,500,000	45,000,000	45,000,000
Dunmore	4·84	4	11,616,000	4·84	2	5,808,000	—	—	—	—	—	—	3·91	7	37,422,000	4·84	3	8,712,000	11,616,000	51,942,000
Falkirk	5·15	8	24,720,000	5·15	3	9,270,000	—	—	—	—	—	—	1·32	5	3,960,000	15·73	5	41,190,000	24,720,000	54,420,000
Slamannan, etc. ..	31·96	3¾	71,910,000	31·96	1	19,176,000	—	—	—	—	—	—	—	—	—	34·17	5	47,190,000	71,910,000	66,366,000
Larbert	—	—	—	—	—	—	—	—	—	—	—	—	15·13	5	45,390,000	—	—	—	—	45,390,000
Polmont	—	—	—	—	—	—	—	—	—	—	—	—	3·44	7	14,448,000		—		—	14,448,000
Lennoxtown	—	—	—	—	—	—	—	—	—	12·00	2	14,400,000	—	—	—	—	—		—	14,400,000
Kinneil Kerse	—	—	—	—	—	—	—	—	—	2·19	4	5,256,000	2·11	5	6,330,000	—	—		—	11,586,000
CLACKMANNANSHIRE—																				
Alloa	13·19	10½	83,097,000	13·19	3½	23,742,000	—	—	—	0·98	Unknown		9·47	10	56,820,000	19·83	6	71,388,000	83,097,000	151,950,000
FIFE AND KINROSS—																				
Pittenweem and Elie ..	—	—	—	1·00	30	18,000,000	—	—	—	—		—	—	—	—		—		—	18,000,000
Dysart	13·19	25	197,850,000	13·19	4	31,656,000			—	—	—	—	—	—	—	16·55	20	198,600,000	197,850,000	230,256,000
Wemyss	5·40	35	113,400,000	5·40	20	64,800,000	—	—	—	—	—	—	6·50	20	78,000,000	5·40	20	64,800,000	113,400,000	207,600,000
Carriston	—	—	—	—	—	—	6·79	8	32,592,000	6·79	4	16,296,000	—	—	—		—	—	32,592,000	16,296,000
Clatto	—	—	—	—	—			—	—	0·58	2	696,000	—		—	—	—		—	696,000

TABLE I. *Continued.*

Name of County and District.	Upper Coal-measures.						Carboniferous Limestone.												Totals of Available Coal.	
	Coal-seams being worked.			Thin and uncertain Coal-seams, etc.			Surface-exposure. Coal-seams being worked.			Surface-exposure. Thin and uncertain Coal-seams, etc.			Coal-seams lying below the Millstone Grit.			Coal-seams lying below the Upper Coal-measures.				
	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Proven.	Reserves.
	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Tons.	Tons.
FIFE AND KINROSS – *Continued.*																				
Kilmux	—	—	—	—	—	—	4·01	15	36,090,000	4·01	10	24,060,000	—	—	—	—	—	—	36,090,000	24,060,000
Teasses	—	—	—	—	—	—	8·12	5	24,360,000	8·12	5	24,360,000	—	—	—	—	—	—	24,360,000	24,360,000
Ceres	—	—	—	—	—	—	0·86	20	10,320,000	0·86	20	10,320,000	—	—	—	—	—	—	10,320,000	10,320,000
Lathallan	—	—	—	—	—	—	6·84	8	32,832,000	6·84	2	8,208,000	—	—	—	—	—	—	32,832,000	8,208,000
Lochty	—	—	—	—	—	—	18·70	6	67,320,000	18·70	4	44,880,000	—	—	—	—	—	—	67,320,000	44,880,000
Drumcarrow	—	—	—	—	—	—	—	—	—	1·20	2	1,440,000	—	—	—	—	—	—	—	1,440,000
Kirkcaldy	—	—	—	—	—	—	8·40	20	100,800,000	8·40	6	30,240,000	—	—	—	—	—	—	100,800,000	30,240,000
Kinglassie	—	—	—	—	—	—	2·20	14	18,480,000	2·20	3	3,960,000	—	—	—	—	—	—	18,480,000	3,960,000
Capledrae	—	—	—	—	—	—	2·03	2	2,436,000	2·03	12	14,616,000	—	—	—	—	—	—	2,436,000	14,616,000
Lochgelly and Bowhill..	—	—	—	—	—	—	10·75	30	193,500,000	10·75	14	90,300,000	—	—	—	—	—	—	193,500,000	90,300,000
Blairadam and Kelty ..	—	—	—	—	—	—	12·74	20	152,880,000	12·74	7	53,508,000	—	—	—	—	—	—	152,880,000	53,508,000
Dunfermline and Cowdenbeath	—	—	—	—	—	—	8·80	35	184,800,000	8·80	10	52,800,000	—	—	—	—	—	—	184,800,000	52,800,000
West of Fife	—	—	—	—	—	—	18·59	5	55,770,000	18·59	10	111,540,000	3·21	10	19,260,000	—	—	—	55,770,000	130,800,000
Dollar and Blairingone	1·19	6	4,284,000	—	—	—	—	—	—	—	—	—	—	—	—	1·19	6	4,284,000	4,284,000	4,284,000
EDINBURGHSHIRE—																				
Niddrie and Millerhill .	9·10	30	163,800,000	9·10	10	54,600,000	1·04	40	35,193,600	1·04	20	17,596,800	0·35	60	10,500,000	9·10	60	327,600,000	198,993,600	410,296,800
Inveresk	—	—	—	—	—	—	1·12	20	13,440,000	1·12	5	3,360,000	2·01	25	30,150,000	—	—	..	13,440,000	33,510,000
Loanhead, etc.	9·80	15	88,200,000	9·80	2	11,760,000	2·60	55	120,978,000	2·60	25	54,990,000	7·00	40	193,200,000	9·80	40	235,200,000	209,178,000	495,150,000
Penicuik	—	—	—	—	—	—	5·40	10	32,400,000	5·40	5	16,200,000	—	—	—	—	—	—	32,400,000	16,200,000
Newbattle	—	—	—	—	—	—	6·87	40	181,368,000	6·87	6	27,205,200	—	—	—	—	—	—	181,368,000	27,205,200
Vogrie and Pathhead ..	—	—	—	—	—	—	4·85	6	17,460,000	4·85	2	5,820,000	—	—	—	—	—	—	17,460,000	5,820,000
Temple	—	—	—	—	—	—	9·30	4	22,320,000	9·30	2	11,160,000	—	—	—	—	—	—	22,320,000	11,160,000
Brunstane	—	—	—	—	—	—	9·10	4	21,840,000	9·10	2	10,420,000	3·96	4	9,360,000	—	—	—	21,840,000	19,780,000
West Calder .. .	—	—	—	—	—	—	4·60	2	5,520,000	—	—	—	—	—	—	—	—	—	5,520,000	—
HADDINGTONSHIRE—																				
Tranent	..	—	—	—	—	—	4·54	15	40,860,000	4·54	5	13,620,000	—	—	—	—	—	—	40,860,000	13,620,000
Cousland, etc.	—	—	—	—	—	—	—	—	—	4·17	10	25,000,000	—	—	—	—	—	—	—	25,000,000
Ormiston	—	—	—	—	—	—	13·76	10	82,560,000	13·76	2	16,512,000	—	—	—	—	—	—	82,560,000	16,512,000
Prestongrange .. .	—	—	—	—	—	—	0·68	30	12,240,000	0·68	7	2,856,000	—	—	—	—	—	—	12,240,000	2,856,000
LINLITHGOWSHIRE—																				
Westcraigs & Armadale	17·83	7½	80,235,000	17·83	1	10,698,000	—	—	—	—	—	—	2·60	6	9,360,000	17·83	6	64,188,000	80,235,000	84,246,000
Benhar	5·90	12	42,480,000	5·90	5	17,700,000	—	—	—	—	—	—	5·76	10	34,560,000	5·90	6	21,240,000	42.480,000	73,500,000
Crofthead	—	—	—	—	—	—	1·60	10	9,600,000	6·07	2	7,284,000	—	—	—	—	—	—	9,600,000	7,284,000
Bathgate .. .	—	—	—	—	—	—	3·23	6	11,628,000	3·23	2	3,876,000	—	—	—	—	—	—	11,628,000	3,876,000
West Calder to Champfleurie	—	—	—	—	—	—	12·75	2	15,300,000	—	—	—	—	—	—	—	—	—	15,300,000	—
Linlithgow and Bo'ness	—	—	—	—	—	—	10·70	8	51,360,000	10·70	4	25,680,000	1·00	5	3,000,000	—	—	—	51,360,000	28,680,000

Kilmarnock districts there is a thickness of about 10 feet of coal in seams between 1 and 2 feet thick in addition to the above-mentioned 38 feet, and, similarly, there are 6 or 8 feet of thin coal-seams at Old Cumnock and New Cumnock. These seams are included in the columns for unproven coal. The total of this reserve coal in Ayrshire, over 1,000,000,000 tons, is greater than that of any other county.

The Limestone Measures in the southern portion of Ayrshire, at Muirkirk, Guelt, and Patna, show a thickness of from 15 feet to 40 feet of coal in seams of various quality and thickness.

A line of disturbance can be drawn through Girvan, Kirkmichael, Ochiltree and Catrine, which manifests itself in faults and volcanic necks. The areas mentioned above as containing the coal-seams lie south-east of this line of disturbance ; but on the north-west there is a remarkable thinning-out of the Limestone Measures, and the coal-seams are few in number and inferior in quality. The outcrop of this formation as exposed south-west of Coylton, is thin, and at some places seems to be altogether wanting—the Coal-measures resting directly on the Calciferous Sandstone. On the northern edges of the basin, as at Craigie Stewarton and Loudoun, where the Limestone Measures again come to the surface, the coal-seams are either absent or very thin and unworkable. Towards the north-western edge of the basin, near Kilwinning and Saltcoats, a few workable seams have been found. A bore-hole at Caprington, near Dreghorn, reached the Limestone Measures at a depth of about 780 feet and was continued to a total depth of 1,608 feet. Only three seams of coal were found in the Limestone Measures having an aggregate thickness of 5 feet 4 inches.

In the Kilwinning area, an average thickness of 4 feet of coal may reasonably be expected in the Limestone Measures, but throughout the remainder of the north-western portion of Ayrshire, the chance of finding coal-seams below the Coal-measures is not great.

There are some prospects of finding coal under the Firth of Clyde, between Ayr and Saltcoats. The appearances at Saltcoats are sufficiently favourable in this respect, but judging by the nature of the strata exposed between Ayr and Irvine the prospects of finding any workable coal-seams below the Firth of Clyde are too slight to permit of the inclusion of any of this area in the estimates. Some coal may ultimately be worked below the New Red Sandstone at Mauchline, but the quantity that may be found at a workable depth is very uncertain, and it has not been included in the estimates.

Lanarkshire.—The district of the Clyde basin as defined by the outcrop of the Ell coal-seam has an area of 62·3 square miles. In the Coal-measures, the seams, from the Virgin coal-seam upwards to the Glasgow Upper coal-seam, represent a total thickness varying from 16 to 28 feet, and an average thickness for the whole district of 20 feet of workable coal has been estimated.

Below the Virgin coal-seam there are two groups of lower seams, (1) the Virtuewell, Kiltongue and Drumgray seams and (2) the Shotts seams. The Shotts coal-seams are represented by a few thin seams which may be ultimately worked in some parts of the area. In the shallower parts of the coal-field to the north and east, the coal-seams from the Virtuewell to the Lower Drumgray have an average thickness of about 8 feet. In the south-western portion of the basin, from Glasgow to Hamilton, several bore-holes have been put down to the lower seams. These bore-holes seem to indicate that the prospect of finding lower seams throughout this part of the district is not very promising. Under these circumstances, an average thickness of 5 feet of coal for the whole area is as much as can be safely estimated as the workable thickness.

The 2 feet of coal represents the Musselband coal-seam between the Splint and the Virtuewell, the Ladygrange, the Lower Kiltongue and whatever coal-seams may be found below the Lower Drumgray seam.

In dealing with the Limestone Measures underlying the upper coal-seams of the Clyde basin, it is estimated that, even in the deepest part of the field, they will be found within a workable depth. The thickness of coal which may be estimated in these measures is very uncertain. Where the seams come to the surface at the western edge of the basin, the thickness of workable coal is 10 feet. On the northern margin of the basin, by Cumbernauld and Nethercroy, there are only a few workable seams. On the east, the Carluke seams attain a maximum thickness of 13 feet. Wherever the Limestone Measures are exposed on the south-western margin of the basin, they exhibit only a few thin seams. From those circumstances, it seems probable that, through the north-eastern portion of the Clyde basin, 6 to 12 feet of coal may be found in the Limestone Measures, and that this thickness will decrease towards the south-western portion of the basin. Taking the average throughout the whole area, and allowing for intrusive whins, an average thickness of 2 feet is probably as much as will ever be worked.

There seems to be a better prospect of finding the coal-seams of the Limestone Measures throughout a large part of the area of Chapelhall,

Harthill and Newmains. From the extent of the outcrop of the Millstone Grit to the east of this area, it would appear probable that the distance from the Slatyband ironstone to the Levenseat limestone is between 300 and 600 feet. This estimate would place the depth of the Limestone Measures in this area at between 1,800 and 2,400 feet; and from the surrounding outcrops at Wilsonton, Crofthead and Bathgate, the thickness may be estimated at from 6 to 8 feet of coal.

The large area of Limestone Measures, near East Kilbride and Quarter, seems to be almost barren of workable seams. Near East Kilbride, some thin seams have been worked to a small extent, having a thickness of 3 to 4 feet of coal, but an average for the whole area of 2 feet of thin coal-seams probably represents the greatest quantity that can be fairly estimated.

Dumbartonshire and Stirlingshire.—In the Kirkintilloch and Kilsyth districts, the maximum section from the Hirst coal-seam to the Kilsyth Main coal-seam contains over 20 feet of workable coal and about 10 feet in seams varying from 1 to 2 feet in thickness.

Towards the east, at Denny, the seams thin out, but on going farther east to Bannockburn several seams of good workable quality are found.

To the west of Kirkintilloch, in the Lennoxtown district, the coal-seams are thin and troubled. A bore-hole, near Balmore, passed through four seams at a depth between 900 and 960 feet, having an aggregate thickness of 6 feet.

In the New Kilpatrick district, there are some workings in the Hurlet coal-seam, and at Garscube coal-seams aggregating 12 feet in thickness have been found.

In the Slamannan district, the average thickness of 3¾ feet has been found by taking the area of each seam to its outcrop and averaging the thickness over the whole area. The 12 inches of thin coal includes any of the Shotts or Bathgate coal-seams that may be found throughout the Slamannan district, and there are also the Musselband coal-seam and a 13 inches coal-seam sometimes found below the Kiltongue seam.

The officers of the Geological Survey have estimated, from bore-holes on the Callander and South Drum estates, that the distance from the Slatyband ironstone to the Arden limestone is about 1,000 feet. On this basis, the coal-seams of the Carboniferous Limestone Series should be found throughout the Slamannan and Falkirk districts at a depth not exceeding 2,400 feet. In the writer's estimate, 5 feet has been allowed for those coal-seams, including the Hirst coal-seam.

Linlithgowshire.—The only item calling for special comment in this county is the inclusion of the coal-seams of the Calciferous Sandstone Series in the West Calder district. The Two-feet and the Houston seams represent about 6 or 7 feet of coal, but in the estimates an average of only 2 feet has been taken, as there may be areas in which these seams are too poor in quality to be ever worked.

Fifeshire.—The Upper Coal-measures of the Wemyss and Dysart coal-fields contain seventeen seams varying in thickness from 1¼ feet to 20 feet, and representing an aggregate thickness of 78 feet of coal. In the Dysart district, only the lower seams are found from the More coal-seam downwards, and these seams are taken at an average thickness of 25 feet, with 4 feet of thin coal seams.

The Wemyss area includes both the upper and lower coal-seams, an average thickness of 35 feet representing the coal at present workable, but an additional thickness of 20 feet may represent the various underlying seams which will be undoubtedly worked in the future.

The Millstone Grit as exposed east of Dysart has a thickness of about 900 feet, and it is estimated that the Carboniferous Limestone coal-seams will be found throughout the Wemyss and Dysart field at a depth varying from 1,500 to 2,700 feet.

To the west and north of this basin, the coal-seams of the Limestone Measures have a thickness varying from 8 to 20 feet, and on the east, at Pittenweem, an aggregate thickness of 40 feet. An estimate of 20 feet of coal in the Limestone Measures below Dysart and Wemyss appears reasonable.

In the district north of Largo, the coal-seams are disturbed by intrusive whinstone, but allowance has been made for any loss when considering the separate areas from Carriston to Drumcarrow.

At Ceres, there is a remarkable basin containing about 17 coal-seams, with an aggregate thickness of over 60 feet, but the area containing these seams does not extend beyond a few hundred feet.

At Lochty and Balcascie, coal has been worked in the Calciferous Sandstone Series, from four seams having an aggregate thickness of 15 to 17 feet, but the quality is rather poor.

In the central area of Fifeshire, the recent sinkings at Bowhill, Glencraig, etc., have demonstrated that the Dunfermline seams extend throughout a very large area, with a total thickness varying from 20 to 30 feet.

Between Dunfermline and Alloa, there is an area of 18·59 square

miles containing seams of the Carboniferous Limestone Series. At Loch Glow, bore-holes show 23 feet of workable coal; at Steelend, near Saline, several seams have been found in shallow pits and bore-holes; and at Bandrum, in the same district, a bore-hole shows 13 feet of coal within a depth of 444 feet. Some bore-holes to the west of Saline struck several thin coal-seams within a depth of 600 feet; but the Dunfermline Splint coal-seam (so far as the writer is aware) has not yet been reached at any point west of Saline. An average of 5 feet over the whole area is as much as may be safely taken in the meantime to represent the thickness of proven coal, but an additional 10 feet has been taken as representing the unproven seams. Below the Millstone Grit, west of Saline and Culross are the Janet Peat coal-seams in addition to the underlying seams. There appears to be a regular thinning-out of the Limestone coal-seams from Dunfermline westwards to Bannockburn and Denny, so that even allowing for the addition of the Janet Peat coal-seam it is hardly safe to count on more than 10 feet of coal below the Millstone Grit in the west of Fife.

Clackmannanshire.—In estimating the coals in the Upper Coal-measures of the Alloa basin, it has been found more convenient to take out the area of each separate seam, and the tonnage has been calculated by this method.

The section from the Upper Five-feet to the Main coal-seam shows a total thickness of about 40 feet of coal, and above the Five-feet seam are a few seams varying in thickness from 1½ feet to 3½ feet.

There is a small area of Carboniferous Limestone Measures in the detached portion of Clackmannan. Some of the Bannockburn coal-seams possibly may be found in this area, but they are too uncertain to permit of the estimation of any definite quantity. The distance from the base of the Coal-measures to the Limestone seams is indicated by the extent of the outcrop of Millstone Grit. As the breadth of this outcrop is nowhere very great, it is probable that the Limestone coal-seams may be found at a moderate depth throughout the Alloa basin. To the west of this basin, at Bannockburn, these coal-seams have a total thickness of about 13 feet. To the east, there is the Janet Peat coal-seam, with a thickness of 6 feet, and below that the other Fifeshire coal-seams probably occur.

As previously remarked, there is a thinning-out of the Carboniferous Limestone coal-seams towards the west of Fife, and, keeping in view the possibility of a further thinning-out towards the centre of the Alloa basin, an average thickness of 6 feet seems to be as much as can be safely estimated for this area.

Edinburghshire.—The seams in this area occupy a trough about 15 miles long by 7 miles wide. The centre of the trough for a length of 8 miles is occupied by the Upper Coal-measures, and the Millstone Grit and Carboniferous Limestone Measures are found cropping out at the edges. The field is divided by a 480 feet fault running through Gilmerton and Dalkeith, and the coal-seams thin to the south of this fault. The thicknesses of coal given have been arrived at by taking in each area the average of the seams actually proved by pits and bore-holes. In estimating the quantity of coal in the Limestone Measures on the western side of the field, an allowance has been made for the dip of the strata. The Limestone coal-seams extend below the Millstone Grit and the Upper Coal-measures, and their depth at the centre of the basin is probably between 2,400 and 3,000 feet.

In estimating the quantity of coal which may be found in the Limestone Measures below the newer formations, it has been considered safer to take the thickness as shown on the eastern side of the basin rather than the thicker coal-seams found on the western side. It is assumed that the whole of the seams are lying at such a depth that they may be ultimately worked. On the western side of the basin, the total thickness of coal in the Limestone series is from 80 to 100 feet. On the eastern side, it is about 50 feet in seams over 2 feet thick and about 10 feet more in seams between 1 and 2 feet in thickness. A total thickness of 60 feet therefore has been taken as the probable thickness of coal in this series below the Upper Coal-measures in the northern part of the basin, and 40 feet has been taken in the southern part to allow for the thinning-out previously mentioned.

There is much valuable information as to the Midlothian coal-field in a memoir written by Mr. David Milne, and published in 1839. Mr. Milne estimated the average thickness of coal in the Upper Coal-measures at 75 feet and in the Carboniferous Limestone Series at 108 feet. On this basis, he estimated the total quantity of coal at 3,000,000,000 tons. As showing how soon an estimate of what may be considered a workable depth becomes modified, a quotation from Mr. Milne's work may be given:

Seve ral of these coal-seams, and the best of them, are at some places at such a depth from the surface as not to be capable of being reached by any means that are either known or likely to be invented. This remark is particularly applicable to the North Greens coal, which affords the largest supplies of parrot coal, and which probably is, all along the trough of the Esk basin, not less than from 500 to 800 fathoms below the surface. It may be safely said that all the coal of this and other seams which are more than 200 fathoms below the surface is entirely unattainable.*

* Page 90.

Firth of Forth.—It is evident that the coal-seams of Fife and Edinburghshires are continuous beneath the Firth of Forth. The width from Musselburgh to Wemyss is about 14 miles, and the depth of water does not exceed 100 feet. In the report of the Royal Commission on Coal, an estimate of 1,800,000,000 tons is given as to the amount of coal which may be recovered from underneath the Forth. Prof. Edward Hull states that this estimate is much too high.*

It seems to the writer a fair estimate to allow for the coal being ultimately worked for a distance of 3 miles from each shore. On this basis, and allowing for two-thirds of the coal remaining as barriers, etc., a total quantity of 1,000,000,000 tons may be reasonably estimated as reserve coal. The coal lying below the Firth of Forth,† opposite to Bo'ness and Grangemouth, has been included (under Linlithgowshire) in Table I.

Dumfriesshire.—The two districts producing coal in this county are at Kirkconnel and Canonbie. In the Kirkconnel and Sanquhar basin, the estimated quantity of coal is 45,000,000 tons in the Upper Coal-measures. The prospects of finding any quantity of the Carboniferous Limestone coal-seams in this area are not encouraging. The Coal-measures on all sides come into direct contact with Silurian rocks and no outcrop of the Limestone Measures is seen. On the south-western edge of the basin this may be explained by assuming that the Upper Coal-measures overlap the underlying Limestone Measures. If this assumption be correct, the Limestone Measures must be very restricted in area. One or two outliers of Limestone Measures are found to the east of Sanquhar, but these are not known to contain any coal-seams. In the estimates no coal has been included for the Carboniferous Limestone Series of this basin.

The writer is indebted to Mr. Kenneth McK. Bowie for information regarding the coal-seams of the Canonbie district.

At Canonbie colliery, there is a small area of Upper Coal-measures exposed. Within a depth of 456 feet are seven workable seams having an aggregate thickness of 37 feet 7 inches. A bore-hole from the pavement of the lowest of those seams was put down to a further depth of 1,350 feet (making 1,860 feet from the surface) and passed through 14 thin coal-seams, the thickest being 2 feet 4 inches thick. At this depth, some thin bands of limestone were found.

* *Our Coal Resources*, page 81.

† *Trans. Inst. M.E.*, vol. xiv., page 239.

From Canonbie southward to the Solway Firth there is a total area of about 80 square miles covered by Permian rocks. In 1869, Sir Archibald Geikie stated that—

As the Coal-measures dip below the Permian Sandstones there can be little doubt that they underly at least the eastern part of the Solway basin. There is absolutely no evidence to indicate how far west they come underneath the Red Sandstones. All that can certainly be affirmed is that they do not reach to the western margin of the basin, and must therefore disappear somewhere under the Red Sandstones. The Permian Sandstones and Marls have recently been well exposed in a continuous section in a railway-cutting near Annan. At that locality, about 600 feet of Red Sandstones and Marls are visible, but as neither the top nor the bottom of the series has been laid open its total thickness must be greater than 600 feet. Such coal-seams, therefore, as pass westward from Canonbie under the Solway basin, must be covered by at least 1,200 feet of Red Sandstones and Shales. It is much to be desired that a series of borings should be made with the view of ascertaining the extent and depth of the coal-seams under this basin. If these borings are undertaken they ought to be carried out systematically under the advice of some competent geologist.*

In 1889, a bore-hole was put down through the Permian Sandstones to a total depth of 1,578 feet. It passed through ten thin coal-seams, the tenth being 2 feet 5 ,inches thick at a depth of 1,542 feet. Mr. Bowie considers that the 2 feet 5 inches seam may correspond with the first coal-seam found at Canonbie colliery at a depth of 138 feet. In the Report of the Royal Commission on Coal a quantity of 150,000,000 tons was estimated to lie below the Permian Measures of the Solway basin, but in view of the great uncertainty as to the extent of the field, this estimate seems optimistic.

The following method has been adopted so as to arrive at an estimate of the coal which has been already worked from each county. Reliable figures of the output of coal have been published since 1854. Prior to that date, the figures are more or less approximate, but Table II., based upon the estimates of the Royal Commission on Coal, may be taken as correct.

TABLE II.†—OUTPUT OF COAL IN UNITED KINGDOM.

	Tons.
1660	2,148,000
1700	2,612,000
1750	4,773,828
1770	6,205,400
1780	6,424,976
1790	7,618,760
1800	10,080,300
1816‡	16,000,000 to 27,000,000

* *Report of the Royal Commission on Coal*, vol. i , page 168.
† *Ibid.*, vol. iii., page 32. ‡ *Ibid.*, page 41.

By plotting those figures in a diagram and continuing the curve backwards to 1400, one can show approximately the amount of coal worked in the United Kingdom* (Fig. 1). The output of Scotland since 1854 has also been plotted on the same diagram. From 1854 to the present date, the output of Scotland has represented on an average 13·3 per cent. of the output of the United Kingdom. The

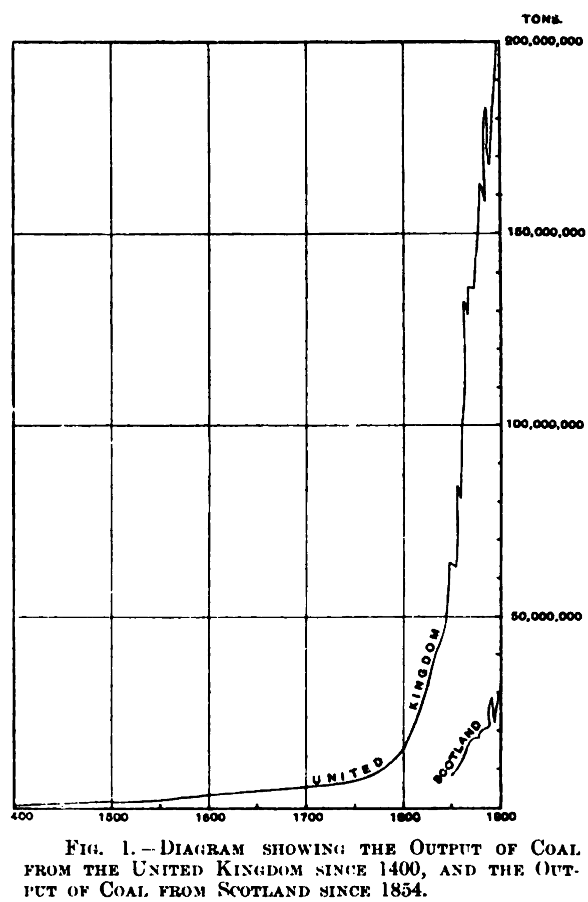


FIG. 1.—DIAGRAM SHOWING THE OUTPUT OF COAL FROM THE UNITED KINGDOM SINCE 1400, AND THE OUTPUT OF COAL FROM SCOTLAND SINCE 1854.

total output of Scotland since 1400 is estimated on the assumption that the Scottish output has always maintained this ratio to the output of the United Kingdom. The author, on this basis, estimates the total amount of coal worked in Scotland to the present date as 1,504,000,000 tons. Since 1876, returns have been published showing

* There were coal-workings prior to 1400, but the quantity worked must have been comparatively unimportant.

the output from each county, and from these returns, the writer estimates that from 1876 to the present date, each county has produced the proportions of the total output as detailed in Table III.

TABLE III.—SHOWING PROPORTION OF TOTAL OUTPUT WROUGHT FROM EACH COUNTY.

Counties.	Per Cent.
Argyll, Dumfries, etc.	0·85
Ayr	14·35
Dumbarton ...	1·40
Lanark ...	55·90
Renfrew	0·35
Stirling	6·05
Clackmannan	1·40
Edinburgh	3·75
Fife and Kinross	11·95
Haddington	1·20
Linlithgow	2·80

The total coal worked from each county has been estimated by allocating a total of 1,540,000,000 tons in proportion to the above percentage, and these figures are detailed in Table IV.

TABLE IV.—SHOWING TOTAL QUANTITY OF AVAILABLE COAL.

County.	Total Available Quantity of Proven Coal.	Quantity Worked.	Total Quantity still to Work.	Estimated Quantity of Unproven Coal in Reserve.
	Tons.	Tons.	Tons.	Tons.
Argyll, Dumfries, Perth, and Sutherland	117,788,000	12,788,000	105,000,000	166,843,1.0
Ayr	1,355,316,000	215,824,000	1,139,592,000	1,066,652,000
Dumbarton	64,992,000	21,056,000	43,936,000	48,714,000
Lanark	1,900,542,000	840,736,000	1,059,806,000	885,324,000
Renfrew	84,036,000	5,264,000	78,772,000	87,184,000
Stirling	256,422,000	90,992,000	165,430,000	349,020,000
Clackmannan ..	83,097,000	21,056,000	62,041,(00	151,950 000
Edinburgh	702,519,600	56,400,000	646,119,600	1,019,122,000
Fife and Kinross ..	1,227,714,000	179,728,000	1,047,986,000	966,624,000
Haddington... ...	135,660,000	18,048,000	117,612,000	57,988,000
Linlithgow	210,003,000	42.112,000	168,491,000	197,586,000
Firth of Forth ...	—	—	—	1,000,000,000

The net result of these calculations shows that the following quantity of coal is still available :—

	Tons.
Proven coal at moderate depths	4,634,785,600
Thin seams and deep seams...	5,897,007,120
Total	10,531,792,720

The question as to how long this coal will last is not one that admits of a very definite answer. The output of coal since 1600 has been steadily progressive, and the problem is how long will this progress

continue? The continued increase of the output is intimately associated with the industrial prosperity of the country, and the increased prosperity is reflected in the increase of population.

The Royal Commission on Coal, when calculating the probable future consumption of coal gave an estimate based on a geometrical increase of population and a diminishing consumption of coal per head of population.* On this theory they prepared a table showing the probable consumption for each census year from 1871 onwards. The total home consumption anticipated by the Royal Commissioners for 1891 was 146,300,000 tons, whereas the actual home consumption was 145,358,265 tons, and the average increase during the last thirty years has been practically the same as that estimated by the Royal Commissioners.

The Royal Commissioners' estimate of population for 1891 was 31,955,000 and the estimated consumption per head of population 4·5786 tons; while the census returns, for 1891, give a population of 37,797,013 and the coal-consumption was 3·846 tons per head of population.

It may be contended that so soon as coal becomes scarce, the export of coal will cease, and we may even commence to import coal; but it must be remembered that there is a very close relation between the export of coal and the cheap supply of food-stuffs and iron-ore to this country. Coal is practically the only heavy article of cargo that vessels can take from this country, and if outward-bound vessels cannot obtain a sufficient cargo, there will be a serious increase in the cost of shipping, which will quickly reflect on the trade of the country. This subject is dealt with very fully by Prof. W. Stanley Jevons in his work on *The Coal Question*. His opinion is clearly expressed in the following quotation: "While the export of coal is a vast and growing branch of our trade, a reversal of the trade and a future return current of coal is a commercial impossibility and absurdity."†

The Royal Commission on Coal stated that "as regards the future exportation of coal . . . there is reason to doubt whether much increase will take place in this direction;"‡ and they assumed that the future export would remain stationary at 12,000,000 tons.

As a commentary on this statement and estimate, the Board of Trade returns for 1897 show that the export of coal from Great Britain was 48,128,464 tons.§ Not only has the total amount sent to foreign countries increased to this remarkable extent, but the propor-

* *Report*, vol. i. page 16. † Page 221. ‡ *Report*, vol. i. page 14.

§ The returns include fuel used by steamers engaged in foreign trade.

tion of the output exported also shows a large increase. During the years 1873 to 1877, the average proportion of exports to home consumption was 16 per cent., while in the years 1893 to 1897 the average proportion of exports to home consumption was nearly 25 per cent.

TABLE V.—SHOWING ESTIMATED OUTPUT OF COAL IN SCOTLAND BASED ON THE ESTIMATE OF CONSUMPTION OF COAL IN THE UNITED KINGDOM AS MADE BY THE ROYAL COMMISSION ON COAL IN 1871.

Year.	United Kingdom. Estimated Consumption.	Scotland. Estimated Consumption on the Basis of 15·2 per cent. of the Consumption of the United Kingdom.	Scotland. Exports on the Basis of 25 per cent. of the Output of Scotland.
	Tons.	Tons.	Tons.
1901	162,400,000	24,684,800	6,171,200
1911	178,000,000	27,056,000	6,764,000
1921	193,200,000	29,366,400	7,341,600
1931 ...	208,700,000	31,722,400	7,930,600
1941	224,800,000	34,169,600	8,542,400
1951	241,100,000	36,647,200	9,161,800
1961	257,600,000	39,155,200	9,788,800
1971	274,200,000	41,678,400	10,419,600
1981	290,800,000	44,201,600	11,050,400
1991	307,400,000	46,724,800	11,681,200
2001	323,900,000	49,232,800	12,308,200
2011	340,300,000	51,725,600	12,931,400
2021	355,700,000	54,066,400	13,766,600
2031	371,700,000	56,498,400	14,124,600
2041	387,400,000	58,884,800	14,721,200
2051	402,800 000	61,225,600	15,306,400
2061	417,900,000	63,520,800	15,880,200
2071	432,700,000	65,770,400	16,442,600
2081	447,000,000	67,944,000	16,986,000
2091	461,000,000	70,072,000	17,518,000

Table V. contains an estimate of the future output of Scotland. Column 1 gives the estimated home consumption of the United Kingdom, taken from the report of the Royal Commissioners on Coal. The output of coal in Scotland during the last 10 years has been on an average equal to 15·2 per cent. of the output of the United Kingdom. Therefore, in column 2, the estimated home consumption of Scotland has been taken at 15·2 per cent. of the consumption of the United Kingdom. The export of coal from Scotland is taken at 25 per cent. of the home consumption, and in this way the third column of the table has been calculated. On the basis of this estimate, all the proven coal in Scotland will be exhausted by the year 1994, and all the reserve coal will be exhausted by the year 2086.

It is of course evident that, long before those dates are reached, the continued increase of the output will have received a check; and that, just

as the output has gradually increased, so also will it gradually diminish. The vital consideration is that within a comparatively short time the mines of Scotland will be unable to supply the necessary coal for the continuance of that increase of the trade and population of the country which has been so marked a feature of the present century. Assuming that the annual increment continues until 1941, when the Scottish output will have reached a total of 40,000,000 tons per annum, there will be sufficient coal left to maintain the output at that rate until the year 2160, but even on this assumption cheaply-worked coal will only last until about the end of next century.

The writer desires to put forward the opinion that the best interests of the industries of the country will be served, at least for some time to come, by maintaining and increasing the present export of coal. As coal becomes more expensive to work, greater facilities will be devised for dealing with the output so as to reduce the cost of working and shipment to a minimum. At the same time, every effort must be made to reduce the home consumption per head of the population by greater economy in the use of fuel and by the development of our natural sources of power. For instance, several million tons of coal per annum are represented by various waterfalls, at present running to waste. Every year that this waste continues means just as many million tons uselessly taken from our strictly limited store. The waste of coal in working is also an item in which considerable economy may still be effected; and the allowance for loss made in the second paragraph of this paper might be considerably reduced, if greater care were taken to minimize the loss caused by leaving barriers around small estates.

TABLE VI.

County.	Proportion of Average Annual Output.	Unwrought Proven Coal.
	Per cent.	Per cent.
Lanark	55·90	22·8
Ayr..	14·35	24·6
Fife	11·95	22·6
Stirling	6·05	3·6
Edinburgh	3·75	13·9
Linlithgow	2·80	3·6
Others	5·20	8·9

In Table VI., column 1 shows the proportion of the average annual output which comes from each county, and column 2 shows the proportion of the 4,634,785,600 tons of proven coal still to work in each of the counties. If each county were producing coal in proportion to

its capacity, as indicated by column 2, the distribution of the output would be very different from what it is at the present moment.

It is evident from Table VI. that the proportion at present produced by Lanarkshire and Stirlingshire cannot be long maintained. The production of Edinburghshire, on the other hand, is extremely small in proportion to the amount of coal contained in that county. The inference from those figures is that we must look especially to Ayrshire and Edinburghshire for future increases of output. The output of Lanarkshire and Stirlingshire is nearly double what it was in 1878, whereas the output of Ayrshire in 1898 was only 500,000 tons more than it was in 1878, and Edinburghshire shows about the same increase. If it were possible for Lanarkshire to continue producing coal at the rate of 55·9 per cent. of the output of Scotland, then all the workable coal in that county would be exhausted in about 40 years, but, on the other hand, there is enough workable coal in Ayrshire to maintain three times the present output for 96 years The output of Fifeshire is now almost three times as great as it was in 1878—a remarkable contrast with the stagnation of Edinburghshire and Ayrshire.

The SECRETARY (Mr. J. Barrowman) said that Mr. Dron must have been at great pains in the preparation of his paper and in tabulating the quantities. The accuracy of the figures would, of course, depend upon the extent to which Mr. Dron had been able to take advantage of all possible sources of information, not only from the geological maps of the various coal-fields, but also from actual developments. As to the reference made by Mr. Dron to loss in working, if mining were conducted in the best possible way there would be very little loss, and he thought that this should be emphasized. There were collieries in Lanarkshire taking out within 2 or 3 per cent. of the whole coal in certain seams. Mr. Dron seemed to be afraid to venture farther out than 3 miles from each shore of the Firth of Forth, in suggesting a probable future working of coal there. He (Mr. Barrowman) believed that the late Dr. Landale, the wellknown mining engineer, had suggested the sinking of a pit on one of the small islands in the Firth and the working of the coal from that point, and shipping of it direct from the pithead.* Considering the moderate depth of the water, the putting down of a shaft in the Firth did not seem a formidable undertaking.

* *Trans. Inst. M.E.*, vol. xiv., page 254.

Mr. R. W. Dron said that, in preparing the estimates, he had taken advantage of many sources of information, including the records of bore-holes and actual developments; and he could assure the members that no effort had been spared to ensure accuracy. The areas had been calculated from the maps of the Geological Survey. With regard to Mr. Barrowman's remarks as to the percentage of coal lost in working, he was gratified to know that some of the collieries in Lanarkshire were taking out about 98 per cent. of the coal. He considered that 75 per cent. was nearer the mark in Ayrshire.

Mr. J. Barrowman said that in some of the collieries in Ayrshire and Fifeshire small coal was systematically left in the workings. He thought that this was a state of matters that should not now be tolerated.

Mr. T. H. Mottram (Glasgow) pointed out that in some collieries in Ayrshire there were no washing-machines, and, in consequence, the small could not be always profitably dealt with. He attributed the success in this respect of the Lanarkshire collieries to the fact that washing-plants were more generally in use there.

Mr. J. Barrowman replied that if washing-machines had anything to do with the success of the Lanarkshire collieries, the sooner there were similar facilities at other collieries the better.

The Chairman (Mr. Smith) stated that at the Dalmellington collieries no dross was left in the workings.

The discussion was adjourned.

THE INSTITUTION OF MINING ENGINEERS.

ANNUAL GENERAL MEETING,

HELD IN THE UNIVERSITY COLLEGE, SHEFFIELD, SEPTEMBER 19TH, 1899.

MR. J. A. LONGDEN, RETIRING PRESIDENT, IN THE CHAIR.

Mr. W. H. CHAMBERS, President of the Midland Institute of Mining, Civil and Mechanical Engineers, welcomed the members to the district. Arrangements had been made for visits to collieries and works, and he trusted that the meeting would be satisfactory to the members.

ELECTION OF OFFICERS, 1899-1900.

The SECRETARY announced the election of the following officers by the Council:—

PRESIDENT.

Mr. H. C. PEAKE.

VICE-PRESIDENTS.

Mr. WM. ARMSTRONG.	Mr. J. S. DIXON.	Mr. JOEL SETTLE.
Mr. T. FORSTER BROWN.	Mr. J. T. FORGIE.	Mr. A. L. STEAVENSON.
Mr. W. H. CHAMBERS.	Mr. G. B. FORSTER.	Mr. F. N. WARDELL.
Mr. WM. COCHRANE.	Mr. W. D. HOLFORD.	Mr. R. S. WILLIAMSON.
Mr. M. DEACON.	Mr. JAS. A. HOOD.	

TREASURERS.

Messrs. LAMBTON & Co., The Bank, Newcastle-upon-Tyne.

AUDITORS.

Messrs. JOHN G. BENSON & SON, Newcastle-upon-Tyne.

The PRESIDENT (Mr. H. C. Peake), then took the chair and moved that the best thanks of the members be given to Mr. J. A. Longden for his services as President of the Institution during the past year.

The vote of thanks was carried with acclamation.

The SECRETARY read the Annual Report of the Council as follows:—

THE TENTH ANNUAL REPORT OF THE COUNCIL.

The Council are pleased to congratulate the members upon the continued success that has attended The Institution of Mining Engineers during its first decade.

The Institution was formed for the promotion of a more general recognition of the status of mining and metallurgical engineering as scientific professions; communication with the Government upon the practical requirements of legislation affecting these industries; and the advancement of the sciences of geology, mining and metallurgy, and their industrial applications, by the reading of communications from members and others, and by discussion.

The six federated societies are the same as last year, namely, the Chesterfield and Midland Counties Institution of Engineers; the Midland Institute of Mining, Civil and Mechanical Engineers; the Mining Institute of Scotland; the North of England Institute of Mining and Mechanical Engineers; the North Staffordshire Institute of Mining and Mechanical Engineers; and the South Staffordshire and East Worcestershire Institute of Mining Engineers.

The following table shows the progress of the membership since the formation of the Institution on July 1st, 1889:—

Year Ending July 31st.	No. of Members.	No. of Non-Federated.	Totals.
1890	1,189	50	1,239
1891	1,187	9	1,196
1892	1,415	19	1,434
1893	1,533	19	1,552
1894	2,068	123	2,191
1895	2,210	109	2,319
1896	2,301	81	2,382
1897	2,447	60	2,507
1898	2,462	47	2,509
1899	2,445	41	2,486

There has been a slight decrease in the membership during the past year, possibly owing to the fact that the list only contains the names of members whose subscriptions for the year have been paid to the federated societies.

The Council urge the members to use their influence in order that the Institution may embrace all societies interested in the advancement of mining, metallurgy and their allied industries. The advantages are considerable, as the members receive all papers read at the meetings of

The Institution of Mining Engineers and of the allied societies, which could not have been obtained otherwise, except at greatly enhanced cost by subscriptions to each of these institutes.

Three general meetings have been held during the past year, namely: in South Staffordshire, North Staffordshire and London, and the Council congratulate the members upon the general excellence of the papers which were communicated at these meetings. The thanks of the Institution are due to the gentlemen who have kindly allowed the members to visit their mines and works. The attendance of members at the general meetings continues to be satisfactory, notwithstanding that they reside in all parts of the kingdom and abroad.

Prizes have been awarded to the writers of the following papers, which are printed in the *Transactions* (vols. xiv. and xv.) for the years 1897-98:—

"The Strength of Pit-props." By Prof. Henry Louis.
"Electric Blasting." By Mr. Wm. Maurice.

The Student's prize has been awarded to Mr. G. Clarence Allsebrook for his essay on "Coal-cutting by Machinery."

The report of the Committee upon "Mechanical Ventilators," by arrangement with the Midland Institute of Mining, Civil and Mechanical Engineers and The North of England Institute of Mining and Mechanical Engineers, has been published in the *Transactions*. The Council trust that further experiments will be made upon mine-ventilators, and the results will be communicated to the members.

Presidential addresses have been delivered during the past year to the members of The Institution of Mining Engineers, by Mr. J. A. Longden; the Chesterfield and Midland Counties Institution of Engineers, by Mr. W. D. Holford; the Midland Institute of Mining, Civil and Mechanical Engineers, by Mr. W. H. Chambers; the North of England Institute of Mining and Mechanical Engineers, by Mr. W. Armstrong; and the North Staffordshire Institute of Mining and Mechanical Engineers, by Mr. J. C. Cadman.

Mr. J. Emerson Dowson contributed a valuable paper on the adoption of "Metric Weights and Measures" in Great Britain, and it was accompanied by a discussion not altogether favourable to the adoption of the metric system.

The papers on geology comprize:—

"The Western Interior Coal-field of America." By Mr. H. Foster Bain.
"The Nullagine District, Pilbarra Gold-field, Western Australia." By Mr. S. J. Becher.

"Mineral Resources of Vancouver and Adjacent Islands, British Columbia." By Mr. Wm. M. Brewer.

"Prospecting in British Columbia." By Mr. Wm. M. Brewer.

"The Kalgoorlie Gold-mines, Western Australia." By Mr. H. F. Bulman.

"Notes on the Glacial Deposit or 'Wash' of the Dearness Valley." By Mr. T. L. Elwen.

"Transvaal Coal-field." By Mr. William Peile.

"Horizontal Thrusting in Joints, Mineral Veins and Faults in the North-west of England, etc." By Mr. C. E. de Rance.

"The Genesis and Matrix of the Diamond." By Mr. C. E. de Rance.

"The Geology of Furness." By Mr. C. E. de Rance.

"The Occurrence of Anhydrite in the North of England, etc." By Mr. C. E. de Rance.

"The Mineral Wealth of Zoutpansberg: the Murchison Range Gold-belt." By Mr. Douglas S.-S. Steuart.

"The Ore-deposits of the Silver Spur Mine and Neighbourhood, Texas, Queensland." By Mr. H. G. Stokes.

"The Douglas Coal-field, Lanarkshire." By Mr. Robert Weir.

"Sulphur-mines in the South of Spain." By Mr. Arthur P. Wilson.

Mining engineering has been dealt with in the following papers:—

"Timbering in the Iron Ore-mines of Cumberland and Furness." By Messrs. John L. Hedley and Wm. Leck.

"Timbering and Supporting Underground Workings." By Mr. George L. Kerr.

"Colliery-consumption." By Mr. J. A. Longden.

"Further Notes on Pit-props." By Prof. Henry Louis.

"The South Staffordshire Mines-drainage Scheme, with Special Regard to Electric-power Pumping." By Messrs. E. B. Marten and Edmund Howl.

"Mining for Gold in the Auriferous Gravels of California, U.S.A." By Mr. George Kent Radford.

The following papers have been contributed on mechanical engineering:—

"The Use and Abuse of Colliery Locomotives." By Mr. W. W. Clayton.

"Description of the Pumping-plant at the Stank and Yarlside Mines in the Furness District of North Lancashire." By Mr. Jas. Davison.

"The Application of Condensers to Winding-engines." By Mr. William Freakley.

"The Compounding of Winding-engines." By Mr. William Freakley.

"Supplementary Notes on the Application of Condensers to Winding-engines." By Mr. William Freakley.

"Supplementary Notes on the Compounding of Winding-engines." By Mr. William Freakley.

"The Working of the Boiler Explosions Acts, 1882 and 1890." By Mr. E. G. Hiller.

"Description of the Machinery and Process of Iron-ore Washing at the Park Mines, in the Furness District of North Lancashire." By Mr. W. Kellett.

"The Automatic Manipulation of Coal and Coke." By Mr. Gilbert Little.

"The Use of Slow-moving Belt-ropes in Shafts." By Mr. Harry Rhodes.

Mine-ventilation, safety-appliances, etc., have been discussed in the following papers :—

"Mechanical Ventilators." By Mr. M. Walton Brown.

"Fire-damp in the Iron-ore Mines of Cumberland and Furness." By Messrs. J. L. Hedley and Wm. Leck.

"The Murgue Recording Volumetric Anemometer." By Mr. D. Murgue.

"Experimental Investigations upon the Theory of the Pitot Tube and the Woltmann Mill." By Mr. A. Rateau.

"The Application of Liquefied Carbonic Acid Gas to Underground Fires." By Mr. George Spencer.

Electricity and its applications have been discussed in the following papers :—

"The Midland Electric Corporation, Limited, and its Bearing on Mining in the South Staffordshire District." By Mr. G. L. Addenbrooke.

"Two Types of Electric Coal-cutters." By Mr. Thomas H. Barr.

"Experiments on the Ignition of Fire-damp and Coal-dust by means of Electricity." By Bergassessor Heise and Dr. Thiem.

"The South Staffordshire Mines-drainage Scheme, with Special Regard to Electric-power Pumping." By Messrs. E. B. Marten and Edmund Howl.

"Electric Blasting." Part IV. By Mr. William Maurice.

"Electric-power Plant at Haunchwood Colliery." By Mr. W. Nowell.

Explosives and blasting have been the subjects of the following papers :—

"Davey-Bickford-Smith Safety Shot-igniter.' By Mr. G. Chesneau.

"Experiments on the Ignition of Fire-damp and Coal-dust by means of Electricity." By Bergassessor Heise and Dr. Thiem.

"Electric Blasting." Part IV. By Mr. William Maurice.

"The Martin and Turnbull System of Water-sprays." By Mr. F. G. Meachem.

"Further Notes on Safety-explosives." By Mr. Wm. Jas. Orsman.

"Safety-explosives." By Mr. Wm. Jas. Orsman.

"The Safety of Modern Mining Explosives, with Special Reference to Methods of Testing." By Mr. L. T. O'Shea.

"The Use of High-pressure Steam as a Possible Substitute for Gunpowder or other Dangerous Explosives in Coal-mining." By Major-General H. Schaw.

The chemistry of coal had been discussed in the following papers :—

"A Contribution to the Chemistry of Coal, with Special Reference to the Coals of the Clyde Basin." By Mr. W. Carrick Anderson.

"Results of the Analysis of Samples of New Zealand Coal and Ambrite, and of Barbados Manjak." By Dr. P. Phillips Bedson.

"Observations on the Relation of Underground Temperature and Spontaneous Fires in the Coal to Oxidation and to the Causes which favour it." By Messrs. John S. Haldane and F. G. Meachem.

Coal-cutting by machinery has been discussed in the following papers :—

"Coal-cutting by Machinery." By Mr. G. Clarence Allsebrook.
"Two Types of Electric Coal-cutters." By Mr. Thomas H. Barr.
"Machine-mining and Pick-mining compared." By Mr. W. D. L. Hardie.
"Notes on Coal-cutting Machinery in Use at Foxfield Colliery." By Mr. Benaiah Parker.

The miscellaneous papers have included :—

"Treatment of Refractory Silver-ores by Chlorination and Lixiviation." By Mr. J. E. Breakell.
"Historical Sketch of the First Institution of Mining Engineers." By Mr. Bennett H. Brough.
"Barometer, Thermometer, etc., Readings for the Year 1898." By Mr. M. Walton Brown.
"Report of the Delegate at the Conference of Delegates of Corresponding Societies of the British Association for the Advancement of Science, Bristol, 1898." By Mr. T. Forster Brown.
"Castle Rings, Cannock Chase." By Mr. W. H. Duignan.
"Underground Certificates in Nova Scotian Coal-mines." By Mr. E. Gilpin, Jun.
"An Improved Ambulance-carriage and Stretcher for Use in Mines." By Mr. H. Richardson Hewitt.
"The Felling of a Chimney." By Mr. Frank Reid.
"The Nodon-Bretonneau Process of Seasoning and Preserving Timber and other Fibrous Substances by Means of Electricity." By Mr. E. G. Vecqueray.
"The Rhenish-Westphalian Coal-Syndicate." By Mr. George Blake Walker.

The members may be congratulated upon the varied scope of the (69) papers printed in the *Transactions* (vols. xvi. and xvii.), and the Council trust that members will continue to send in papers as liberally as heretofore.

"Notes of Papers (218) on the Working of Mines, Metallurgy, etc., from the *Transactions* of Colonial and Foreign Societies and Colonial and Foreign Publications," have been continued, and should prove of value to the members.

Members can purchase, at privileged prices, copies of the *Transactions* of the following "Corresponding Societies":—

The Australasian Institute of Mining Engineers;
The Canadian Mining Institute; and
The Institution of Mining and Metallurgy.

The influence of mining institutes, since the formation of the North of England Institute of Mining and Mechanical Engineers in 1852, may be recognized in the adoption of improved methods of mining and

metallurgical processes, in the progress of technical education, and in advanced knowledge of geology and other sciences.

Since 1852, there have been immense strides in the production of minerals and metals, and especially in the condition of mines and miners. The greater part of these improvements are due to the formation and development of societies devoted to the consideration of methods for the safe working and development of mines and the preservation of human life. During this period, examinations have been instituted for mine managers' certificates, mechanical appliances for getting minerals or improved explosives have become a necessity, fans on the surface have replaced underground furnaces as a means of ventilation, and electricity has been introduced as a motive power.

The object of a mining society is not completely attained unless there be critical and adequate discussion of the papers printed in the *Transactions*. Discussion tests the value of a paper, focuses the experience of the speakers, and frequently elicits further information from the author. The value of discussion consequently depends upon the general body of members, and the value of the *Transactions* is also dependent upon the care with which the individual member revises his share of the discussions. Oral discussion has the advantage of securing the attendance of members desirous of hearing and giving opinions which could not otherwise be obtained, and written discussion records the opinions of members who reside at a distance and are unable to attend the meetings. The value and interest of the *Transactions* are considerably enhanced by the addition of the printed discussions which accompany or follow the papers, but the members should remember that unnecessary increase in the volume of discussion involves expense in arranging the revision of the oral and written remarks.

BOOKS, ETC., ADDED TO THE LIBRARY.

African Review, Nos. 299-356.

Annales des Mines de Belgique, vol. iii., No. 4; vol. iv., Nos. 1-3.

Australasian Institute of Mining Engineers, Transactions, vol. v.

Australian Mining Standard, Nos. 503-549, 551, 552, 555, 556, 559, 560.

British Association for the Advancement of Science, Report of the Sixty-eighth Meeting, held at Bristol, in September, 1898, octavo, 1,096 pages.

British Society of Mining Students, Journal, vol. xxi., Nos. 1-6; vol. xxii., No. 1.

Canadian Mining Institute, Journal, vols. i. and ii.

Chambers, Trant, A Land of Promise: Western Australia in 1897-98, second edition, demy octavo, 140 pages.

Chemical and Metallurgical Society of South Africa, Journal, vol. i., No. 6-11; vol. ii., Nos. 1-7.

Coal and Iron, Nos. 105-130 and 182-191.

Cory Brothers, British Coal Trade and Freight Circular, August 31st, 1898, to August 31st, 1899.

Engineering and Mining Journal, vol. lxvi., Nos. 5-27; vol. lvxii., Nos. 1-25; vol. lxviii., Nos. 1-11.

Engineering Times, vol. i., Nos. 4 and 5; vol ii., Nos. 1 and 2.

Franklin Institute of the State of Pennsylvania, U.S.A., Journal, vol. clxvi., No. 2-6; vol. clxvii., Nos. 1-6; vol. clxviii., Nos. 1-3.

Geological Society of South Africa, Transactions, vol. iii.

Institution of Mining and Metallurgy, Transactions, vol. vi.

Lake Superior Mining Institute, Proceedings, vols. i.-iv.

Manchester Geological Society, Transactions, vol. xxv., Nos. 17-21; vol. xxvi, Nos. 1-6.

Massachusetts Institute of Technology, Technology Quarterly, vol. xi., Nos. 2 and 4; vol. xii., Nos. 1 and 2.

Mines and Quarries. Third Annual General Report upon the Mineral Industry of the United Kingdom of Great Britain and Ireland for the year 1896, by C. Le Neve Foster, foolscap folio, 193 pages.

New South Wales, Chamber of Mines: Memorandum and Articles of Association, demy octavo, 17 pages.

— — —, — — —: Three letters on the Australian Mining Laws, written to the *Sydney Daily Telegraph* by Charles J Alford, demy octavo, 13 pages.

— — —. Department of Mines. Annual Report, 1897.

— — —. Geological Survey, Memoirs, Ethnological Series, No 1; Palaeontological Series, No. 6.

— — —. — —. Mineral Resources, Nos. 3-5.

— — —. — —. Records, vol. vi., Nos. 1-3.

New Zealand Institute of Mining Engineers, Transactions, vols. i. and ii.

New Zealand Mines Department, Report for the year 1898.

South African Republic, Annual Reports of State Mining Engineer, 1897 and 1898.

South Wales Institute of Engineers, Transactions, vol. xxi., Nos. 1-4.

Western Australia, Department of Mines, Gold Mining Statistics, 1897, foolscap folio, 123 pages.

EXCHANGES.

Annales des Mines de Belgique,
Australasian Institute of Mining Engineers.
British Association for the Advancement of Science.
British Society of Mining Students.
Canadian Mining Institute.
Chemical and Metallurgical Society of South Africa.
Franklin Institute of the State of Pennsylvania, U.S.A.
*General Mining Association of the Province of Quebec, Canada.
Institution of Mining and Metallurgy.
Lake Superior Mining Institute.
Manchester Geological Society.
Massachusetts Institute of Technology.
*Mining Society of Nova Scotia, Canada.
New South Wales, Department of Mines and Agriculture, Geological Survey.
New Zealand Institute of Mining Engineers.
*Revue Universelle des Mines, de la Métallurgie, etc.
South African Republic, Department of the State Mining Engineer.
South Wales Institute of Engineers.

* No publications received during current year.

July 31st, 1899.

THE LOCAL INSTITUTES IN ACCOUNT WITH THE INSTITUTION OF MINING ENGINEERS, FOR THE YEAR ENDING JULY 31ST, 1899.

Dr.	No. of Members. Federated.	No. of Members. Non-Federated.	Balance due at the beginning of the year. £ s. d.	Amounts falling due during the year. Calls made during the year. £ s. d.	Excerpts. £ s. d.	Transactions, Reducing Plates, etc. £ s. d.	Totals. £ s. d.
Chesterfield and Midland Counties Institution of Engineers ...	306	...	30 2 8	290 14 0	6 4 0	18 3 4	345 4 0
Midland Institute of Mining, Civil and Mechanical Engineers	266	...	10 5 4	252 14 0	3 17 8	3 6 8	270 3 8
Mining Institute of Scotland	419	41	8 7 2	418 11 0	5 12 0	6 13 4	439 3 6
North of England Institute of Mining and Mechanical Engineers	1,170	...	146 11 5	1,111 10 0	21 14 3	27 19 4	1,307 15 0
North Staffordshire Institute of Mining and Mechanical Engineers	149	...	10 5 8	141 11 0	2 5 0	5 13 4	159 15 0
South Staffordshire and East Worcestershire Institute of Mining Engineers...	120	...	33 1 2	114 0 0	0 19 2	12 3 4	160 3 8
Totals	2,430	41	238 13 5	2,329 0 0	40 12 1	73 19 4	2,682 4 10

Cr.	Amounts paid during the year. Balance from previous year. £ s. d.	Calls. £ s. d.	Excerpts. £ s. d.	Transactions, Reducing Plates, etc. £ s. d.	Totals. £ s. d.	Balance due at July 31st, 1899. £ s. d.
Chesterfield and Midland Counties Institution of Engineers ...	30 2 8	239 8 0	6 4 0	11 6 8	287 1 4	58 2 8
Midland Institute of Mining, Civil and Mechanical Engineers	10 5 4	247 0 0	3 17 8	2 16 8	263 19 8	6 4 0
Mining Institute of Scotland	8 7 2	417 12 0	5 12 0	5 0 0	436 11 2	2 12 4
North of England Institute of Mining and Mechanical Engineers	146 11 5	1,047 17 0	21 14 3	26 19 4	1,243 2 0	64 13 0
North Staffordshire Institute of Mining and Mechanical Engineers	10 5 8	128 5 1	1 9 3	...	140 0 0	19 15 0
South Staffordshire and East Worcestershire Institute of Mining Engineers	33 1 2	92 3 0	...	...	125 4 2	34 19 6
Totals	238 13 5	2,172 5 1	38 17 2	46 2 8	2,495 18 4	186 6 6

Dr. THE TREASURER IN ACCOUNT WITH
FOR THE YEAR

		£ s. d.	£ s. d.
July 31, 1898.			
To Balance at Bank		449 5 7	
" " in Treasurer's hands		23 3 3	
			472 8 10
To Subscriptions for year ending July 31, 1898—			
Federated—			
Chesterfield and Midland Counties Institution of Engineers	£22 16 0		
Midland Institute of Mining, Civil and Mechanical Engineers	7 12 0		
Mining Institute of Scotland	0 19 0		
North of England Institute of Mining and Mechanical Engineers	101 13 0		
North Staffordshire Institute of Mining and Mechanical Engineers	6 13 0		
South Staffordshire and East Worcestershire Institute of Mining Engineers ...	24 14 0		
		164 7 0	
Non-Federated—			
Mining Institute of Scotland		0 10 0	
			164 17 0
To Subscriptions for year ending July 31, 1899—			
Federated—			
Chesterfield and Midland Counties Institution of Engineers	£239 8 0		
Midland Institute of Mining, Civil and Mechanical Engineers	247 0 0		
Mining Institute of Scotland	397 2 0		
North of England Institute of Mining and Mechanical Engineers	1,047 17 0		
North Staffordshire Institute of Mining and Mechanical Engineers	128 5 1		
South Staffordshire and East Worcestershire Institute of Mining Engineers ...	92 3 0		
		2,151 15 1	
Non-Federated—			
Mining Institute of Scotland		20 10 0	
			2,172 5 1
Carried forward			£2,809 10 11

THE INSTITUTION OF MINING ENGINEERS. **Cr.**
ENDING JULY 31, 1899.

	£ s. d.	£ s. d.	£ s. d.	£ s. d.
July 31, 1899.				
By Printing—				
Transactions, Vol. XIII., plates	12 1 0			
		12 1 0		
„ „ XIV., printing	32 15 0			
„ „ „ plates	4 15 0			
		37 10 0		
„ „ XV., printing	349 2 4			
„ „ „ plates	144 1 6			
		493 3 10		
„ „ XVI., printing	404 5 0			
„ „ „ plates	108 19 1			
		513 4 1		
„ „ XVII., plates	2 14 8			
		2 14 8		
			1,058 13 7	
Excerpts, Vol. XIII.		7 15 0		
„ „ XIV.		4 1 6		
„ „ XV.		62 15 1		
„ „ XVI.		50 4 7		
			124 16 2	
Indices		......	70 10 0	
Circulars		......	23 16 0	
Proofs of Papers for General Meetings		......	15 14 7	
				1,293 10 4
By Addressing *Transactions*		......	52 10 2	
„ Postages—Circulars		21 11 11		
„ „ Correspondence		20 0 2		
„ „ *Transactions*		301 7 6		
			342 19 7	
„ Stationery, etc.		......	112 1 6	
„ Insurance of *Transactions*		......	3 8 1	
„ Binding—Library		5 1 9		
„ „ Sundries		0 18 9		
„ „ *Transactions*		45 2 2		
			51 2 8	
„ Reporting General Meetings		......	21 11 6	
„ Expenses of General Meetings ...		......	12 11 0	
„ Incidental Expenses		......	3 10 3	
„ Petty Cash		......	8 13 5	
„ Salaries, Wages, Auditing, etc. ...		......	515 4 6	
„ Indexing *Transactions*		......	28 2 4	
„ Travelling Expenses		......	47 13 11	
				1,199 8 11
Carried forward				£2,492 19 3

Dr. THE TREASURER IN ACCOUNT WITH

	£ s. d.	£ s. d.	£ s. d.
Brought forward			2,809 10 11
To Local Publications and Authors' Copies—	1897-98.	1898-99.	
The Institution of Mining Engineers... ...	0 0 0	62 4 9	
Chesterfield and Midland Counties Institution of Engineers	0 0 0	6 4 0	
Midland Institute of Mining, Civil and Mechanical Engineers	0 0 0	3 17 8	
Mining Institute of Scotland	2 11 6	5 12 0	
North of England Institute of Mining and Mechanical Engineers	18 5 9	21 14 3	
North Staffordshire Institute of Mining and Mechanical Engineers	0 6 0	1 9 3	
South Staffordshire and East Worcestershire Institute of Mining Engineers	1 10 6	0 0 0	
	22 13 9	101 1 11	
			123 15 8
To Sales of Transactions, etc.—	1897-98.	1898-99.	
Chesterfield and Midland Counties Institution of Engineers	7 6 8	8 16 8	
Midland Institute of Mining, Civil and Mechanical Engineers	2 13 4	2 16 8	
Mining Institute of Scotland	3 6 8	3 0 0	
North of England Institute of Mining and Mechanical Engineers	26 13 8	24 9 4	
North Staffordshire Institute of Mining and Mechanical Engineers	3 6 8	0 0 0	
South Staffordshire and East Worcestershire Institute of Mining Engineers	6 6 8	0 0 0	
Members and others	0 0 0	201 2 6	
	49 12 8	240 5 2	
			289 17 10
To Reducing Plates—	1897-98.	1898-99.	
Chesterfield and Midland Counties Institution of Engineers	0 0 0	2 10 0	
Midland Institute of Mining, Civil and Mechanical Engineers	0 0 0	0 0 0	
Mining Institute of Scotland	1 0 0	2 0 0	
North of England Institute of Mining and Mechanical Engineers	0 0 0	2 10 0	
North Staffordshire Institute of Mining and Mechanical Engineers	0 0 0	0 0 0	
South Staffordshire and East Worcestershire Institute of Mining Engineers	0 10 0	0 0 0	
	1 10 0	7 0 0	
			8 10 0
To Advertizements			752 16 3
			£3,984 10 8

THE INSTITUTION OF MINING ENGINEERS.—*Continued.* **Cr.**

	£ s. d.	£ s. d.	£ s. d.
Brought forward			2,492 19 3
By Advertizements—Commission	......	196 19 7	
" " Printing	......	4 1 6	
			201 1 1
" Prizes, Vols. XIV. and XV.	10 0 0		
" " Students' Essay, Vol. XVI. ...	5 0 0		
		15 0 0	
" Translations of Papers	......	9 5 0	
" Abstracts of Foreign Papers, Vols. XV. and XVI.	......	142 6 5	
" Barometer Readings, etc.	......	6 3 6	
" Calendars...	......	15 4 6	
" Mechanical Ventilators Committee ...	......	1 0 0	
" Stock-rooms, etc.	......	14 17 5	
			203 16 10
" Balance at Bank		1,063 14 8	
" " in Treasurer's hands		22 18 10	
			1,086 13 6
			£3,984 10 8

We have examined the above account of receipts and payments, with the books and vouchers relating thereto, and certify that in our opinion it is correct.

JOHN G. BENSON & SON,
Chartered Accountants.

Newcastle-upon-Tyne.
September 8*th*, 1899.

THE INSTITUTION OF MINING

Liabilities.

	£ s. d.	£ s. d.
Sundry Creditors—		
Advertizements Paid in Advance	43 0 0	
Printing, etc.	783 9 2	
Postage of Transactions	150 0 0	
Abstracts of Foreign Papers	80 0 0	
Barometer Readings	8 0 0	
Prizes for Papers in Vols. XVI. and XVII.	20 0 0	
Index, Vol. XVII.	15 0 0	
Advertizement Commission, &c.	30 10 10	
		1,130 0 0
Balance of Assets over Liabilities		1,098 1 1
		£2,228 1 1

We have examined the above Balance Sheet, with the books and vouchers relating thereto, and certify that in our opinion it exhibits a correct view of the affairs of the Institution.

We have accepted the asset "Transactions in Stock" as valued by the Officials of the Institution.

JOHN G. BENSON & SON,
Chartered Accountants.

Newcastle-upon-Tyne,
February 10th, 1900.

ENGINEERS.—BALANCE SHEET, JULY 31, 1899.

Assets.

	£ s. d.	£ s. d.
Balance at Bank	1,063 14 8	
„ in hand	22 18 10	
		1,086 13 6
Subscriptions Unpaid, Year ending July 31, 1899—		
Federated—		
Chesterfield and Midland Counties Institution of Engineers	51 6 0	
Midland Institute of Mining, Civil and Mechanical Engineers	5 14 0	
Mining Institute of Scotland	0 19 0	
North of England Institute of Mining and Mechanical Engineers	63 13 0	
North Staffordshire Institute of Mining and Mechanical Engineers	13 5 11	
South Staffordshire and East Worcestershire Institute of Mining Engineers	21 17 0	
		156 14 11
Local Publications and Authors' Copies Unpaid—		
North Staffordshire Institute of Mining and Mechanical Engineers	0 15 9	
South Staffordshire and East Worcestershire Institute of Mining Engineers	0 19 2	
		1 14 11
Transactions Sold—		
The Institution of Mining Engineers	1 8 6	
Chesterfield and Midland Counties Institution of Engineers	6 16 8	
Mining Institute of Scotland	0 13 4	
North of England Institute of Mining and Mechanical Engineers	1 0 0	
North Staffordshire Institute of Mining and Mechanical Engineers	5 13 4	
South Staffordshire and East Worcestershire Institute of Mining Engineers	11 13 4	
		27 5 2
Reducing Plates—		
Midland Institute of Mining, Civil and Mechanical Engineers	0 10 0	
Mining Institute of Scotland	1 0 0	
South Staffordshire and East Worcestershire Institute of Mining Engineers	0 10 0	
		2 0 0
Advertizements unpaid		165 3 4
		1,439 11 10
Transactions in Stock		788 9 3
		£2,228 1 1

THE RATING OF COAL-MINES.

By GEORGE HUMPHREYS-DAVIES.

From the earliest times, the duty of providing for the relief of the "lame, impotent, old, blind and such other among them being poor and not able to work" appears to have been borne by the owners of real property. This was probably because, until law and order were efficiently established, it was not possible to carry on any trade or manufacture which was productive of substantial profit. In the forty-second year of the reign of Elizabeth the condition of the country had, however, so far improved that Parliament passed an Act by which the burden was thrown upon the occupiers of lands, houses, tithes, coal-mines and saleable underwood. It is under this Act that coal-mines and profits derived from stocks-in-trade were made rateable. Coal-mines were no doubt specially mentioned, because coal had then been found to be a valuable commodity and its use had become considerable.

The principles upon which property liable to be rated had to be assessed was laid down by Parliament in the year 1836, and remains practically unaltered. By the Act of 6 and 7 William IV., cap. 96, it was declared that no rate should be valid which was "not made upon an estimate of the net annual value of the several hereditaments rated thereunto, that is to say, of the rent at which the same might reasonably be expected to let from year to year free of all usual tenants' rates and taxes and tithe-commutation rent-charge, if any, and deducting therefrom the probable average annual cost of the repairs, insurance and other expenses, if any, necessary to maintain them in a state to command such rent."

Doubts as to the policy of rating stocks-in-trade and trade-profits appear to have become general in the early part of the present century, and the difficulty of continuing the custom in the face of the recently enacted provisions above quoted was so great that, in 1840, an Act was passed making it unlawful to tax the profits of stocks-in-trade or other similar property for the relief of the poor.

From this statement it will be seen that a coal-mine is to be rated at the sum at which it would let on an ordinary yearly tenancy at the time

when the rate is made, but that from the gross rent which the tenant would pay to the landlord is to be deducted the cost that the landlord would incur for repairs, renewals, and insurance, or, in other words, that the rateable value is to be the net amount of money, which on an average of years a prudent landlord could spend out of his income for his own purposes without the risk of diminishing the amount of that income.

The tenancy contemplated by the Act is to be upon the conditions which the law assumes to be implied in the absence of any express agreement, that is, the rent having been fixed, the tenancy is to continue until one or the other of the parties gives to the other of them at least 6 months' notice to terminate it at the end of any completed year, that is to say, at the same period of the year as that on which it commenced. The tenant is under no liability to repair, insure or renew the property, but must make good any damage not due to reasonable wear and tear.

During the continuance of this tenancy the rent will remain the same, whether the value of the property alter or not. If either party wishes to alter the rent, 6 months' notice must be given, and a fresh tenancy created. For rating purposes, it is to be assumed that both parties are reasonable and fair-minded men who will not seek to alter the rent unless there be such a permanent variation in the circumstances which affect the letting value of the property as to make an increase or diminution of the rent necessary.

As the fundamental idea of the Poor Law has been to make the occupier contribute according to his ability so far as it can be estimated from the property that he occupies at the time when the rate is made, it will be seen that the "annual value" is the best standard by which to judge of this ability.

Various methods are in use in different parts of the country for arriving at the amount at which the occupier of a coal-mine should be rated. It is not necessary for the present purpose to deal with these methods, as the object of the paper is rather to give in such detail as time will permit the principles to be observed in order to carry out the assessment of a coal-mine in accordance with the Acts to which reference has been previously made.

In the first place, it is to be observed that the thing to be rated is neither the produce of the coal-mine nor the profit of the coal-mine, but that the occupier is to be rated at the sum which the landlord or owner would receive as rent for the coal-mine or other property occupied by him.

It appears, therefore, that neither the rent nor royalty, reserved under a mining-lease and fixed for a long term of years, can be a true criterion of the rateable value of the mine when it has been opened under such a lease. Apart from the fact that the royalty itself may be found to be too high or too low, it is manifest that a sum arrived at by taking the aggregate royalties paid during 12 months, after all the profits, advantages and risks of that period have been ascertained, is likely to give a sum entirely different from the fixed sum which a tenant would agree to pay before all those profits, advantages and risks were known or foreseen. This distinction is important, because the law contemplates a certain rent fixed in advance, and not a variable rent fixed in arrear.

Lord Denman said in Regina *versus* Westbrook:—

Still it must always be remembered that the ultimate question is that propounded by the statute; and, therefore, the amount which has been paid, or which it is reasonable to infer will be paid, is only evidence, not the fact itself to be ascertained. When, therefore, the case came to the sessions, it was open to the appellants to prove such uncertainty in the market, or such circumstances affecting the process of making, as showed that the parish officers had done wrong in concluding, from such a quantity made, or expected to be made, that the land might be reasonably expected to let from year to year, at a rent measured by that quantity; such evidence would have raised a question of fact for the sessions, and they would have had, upon the whole, to sustain or reduce the amount of the assessment. It may well be that, although at the end of the year the lessee has made so many bricks that he can afford to pay £150 in royalty to his landlord, he could not prudently, at the beginning of the year, contract, at all events, to pay more than £100; and, if so, the latter rather than the former will be the sum at which the land may reasonably be expected to let from year to year. And this is what we understand the sessions to mean in Westbrook's case by their special finding; the parish officers estimate the rent at a supposed amount of bricks actually made; and the royalty then payable on such amount; from this they make such deductions as reduce the rateable value to £159 10s., but the sessions say that, placing the tenant on exactly the same footing as to the incidents of his occupation, but calling on him to say beforehand what rent he would pay per acre for it, he could not be expected to give more than £10 per acre, which on the whole would amount to a little more than a £100. This latter appears to us to be the true criterion rather than the former, and the rate must be amended accordingly.

It is also to be observed that the unworked coal lying in the seam is not rateable, because it is unoccupied and produces no profit. There is no law which makes rateable an unworked mineral, or indeed any other property producing no profit; and were it otherwise, the difficulty of carrying such a law into effect would be insuperable.

It will also be seen that, immediately coal lying in a seam is separated from that seam, it becomes the stock-in-trade of the colliery-proprietor, and therefore is exempt from rating *per se* under the Act of

1840 already referred to. Further than this, the coal neither in the seam nor when separated, comes under the descriptive words "coal-mine." One is left therefore necessarily to conclude that the words of the Act of Elizabeth were intended to describe the surface-land occupied in raising the coal and the land occupied by the shafts, underground workings and roadways.*

The difficulty of estimating the rent which a tenant from year to year would pay for property of this class is undoubtedly great. The valuation of houses and land is comparatively easy, because a valuer has a large extent of very similar property which is constantly let upon annual tenancies with which he can compare the property that he has to value. This is not so in the case of a coal-mine, because the workings and the difficulties to be contended with vary enormously, even among adjoining mines working the same seams of coal, and further than this, such mines are not let upon annual tenancies. The rent and royalty under a mining-lease afford no criterion of value because the lease for a long term of years is, as a rule, entered upon before coal is won or the difficulties of working it are known. Such a lease is, of necessity, more or less a speculation, because it is an attempt to fix the price and a rent for a thing which cannot be seen and of which even the existence is more or less doubtful.

A mining-lease not only grants a right to occupy and use the land, but also is, in effect, the sale of a part of the soil included in the lease, the purchase-money of which is paid on a system somewhat similar to that adopted by building-societies in connexion with the purchase of house-property.

Another circumstance which prevents a valuer from forming an estimate of the annual rent of a coal-mine by comparison with other mines is, that, although they may be working the same seam of coal, which may be even of the same thickness and quality throughout, yet, owing to differences in the depth and in the nature of the seam and roof, the value of the coal will vary more or less as between each mine. The age of the mine will also affect its value, because, until the coal is fully opened out, it will be more expensive to work, and then after a time it will decrease in value because of the long distance which the coal has to be hauled underground and the additional expense of this haulage and the maintenance of the longer roadways attendant thereon. In this respect it is obvious that the net profit and value to a tenant will be considerably affected by the output of the mine because, although

* The definition of "mine" in *The Century Dictionary* confirms this conclusion.

the actual cost of getting and raising the coal may be a fixed quantity, yet there are certain establishment or standing charges which will remain approximately the same whether the output be large or small. It is therefore obvious that the total expense per ton of coal sold will be greater with a small output than with a large output, because these establishment-charges will be spread over a smaller quantity, while the selling-price of the coal will in each case remain the same.

In Rex *versus* Attwood it was decided that in assessing a coal-mine no deduction could be made for replacing the capital value of the coal which was removed and sold under the lease. It has been contended that this decision means that the coal *quâ* coal is rateable. It is suggested that this inference is incorrect, and that it should rather be assumed that the court meant that the deduction could not be made from the rateable value, because the thing itself, namely, the coal, in respect of which the deduction was claimed was not included in the assessment. Be this as it may, this decision was given in the year 1827, when the profits of stocks-in-trade were rateable, and as we have seen, an Act was subsequently passed exempting such property from the rate. Therefore, it is submitted that the decision in that case is obsolete.

It has been decided that the rent actually paid is not conclusive evidence as to the letting value of the rateable property, but that it is evidence which may be laid before the court. It has also been decided in the case of Dodds *versus* South Shields Union that an Assessment Committee cannot compel the occupier of a property to disclose his profits, yet, by that case and the more recent case in the Court of Appeal of Cartwright *versus* Sculcoats Union it was decided that where a valuer cannot by comparison with similar property in the neighbourhood form a correct estimate of the letting value of the property without enquiry into the receipts and expenses, then such enquiry may be made.

In order to arrive at the correct method of estimating the rent of a "coal-mine," and having pointed out what is excluded from the term, it is necessary to consider what is the nature of the property which does fall under that description.

A coal-mine appears in effect to be nothing but an underground railway of exactly the same nature as the underground railways in London. These tunnels are used for the conveyance of goods and passengers, and, in the case of electric railways, are provided with hydraulic lifts, which are exactly similar in principle to the shafts of a coal-mine. The chief difference is that coal-mines are not constructed

under Parliamentary powers for public use, but under private arrangements between the owner of the soil and the colliery-proprietor. Instead of carrying goods and passengers in return for fares and tolls fixed by Parliament, the underground tunnels and rails are constructed and used by the colliery-proprietor for the carriage of coal belonging to the landowner, who enters into a contract by which the whole risk and expense of getting, raising and selling the coal is thrown upon the contractor by whom the line is constructed and who pays himself in kind and gives the landowner a fixed net price for the coal. Arrangements, in some respects similar, are made with regard to some of the underground and other railways which are leased by the constructing companies to other companies to work at fixed rentals. In some other cases, the railways have been constructed by a contractor who has also taken a lease of the line to be constructed. In these cases it has been held that the receipts, and not the actual rent, are the true criterion of the rateable value.

There are other railways upon the surface used for the conveyance of minerals, some of which are not constructed under Parliamentary powers. The only difference between these railways and the underground workings of a colliery is that they are on the surface instead of beneath it, and in all such cases it is admitted that the receipts and expenses are the true criteria of value.

The writer has made these comments upon the nature of a coal-mine because it appears to him necessary to show that there is no difference in law or in fact, to make colliery-workings rateable on any principle different from that applied to similar property whether upon the surface or underground. If this be the case, the words of the Act of William IV. which define what deductions from the gross value must be made, apply as much to a colliery as to a railway, although the words used to describe the two things may be different.

If the identity of the two things be established, any difficulty disappears as to the principles upon which the gross estimated rental is to be arrived at and upon which the deductions for repairs, renewals and insurance are to be made, because they have been clearly laid down in numerous decisions affecting the rating of railways and similar property.

The principle of arriving at the gross estimated rental of coal-mines by ascertaining the quantity of coal worked in each parish and of placing an estimated royalty per ton upon that coal appears to be adopted in some districts. This course of procedure is fallacious, because it is

impossible by rule of thumb to estimate accurately the value of coal in different parishes, which lies at various depths and is worked at various distances from the shaft, sometimes to the dip and sometimes to the rise, sometimes with a bad roof and with water and other troubles, and sometimes with none of these troubles. Such a method also takes no account of a parish in which little or no coal is being worked, but which has long lengths of roads and airways through which coal is taken from outlying parishes to the shaft. In such a case by this system such a parish, although having a valuable piece of property running through it, would have no rateable value given to it, while a parish in which a large quantity of coal was worked, but in which there was but a short length of road, would obtain the whole of the benefit.

In the case of a surface-railway, it happens frequently that a long length of main line runs through a parish in which there is no station and consequently in which no money is received. Under the system now referred to, such a parish would obtain no rateable value, but the whole would be given to the parishes in which the stations were situated, in accordance with the receipts of these stations.

It was long since held that this was not the correct method, but that the receipts and profits were to be apportioned throughout the whole of the line traversed. It has also been decided, with respect to maintenance and renewal, that their aggregate cost was not to be apportioned equally for the whole line, but that the actual expenses were to be allocated to those parts of the system where they arose, so that a parish which has a piece of line which is expensive to maintain should have that expense thrown upon it, and not be relieved at the expense of other parishes which had better properties.

It is the custom, apparently, in many districts to assess both the gross and rateable values of coal-mines at the same amounts. This custom is presumably based on a supposition either that in the case of coal-mines the occupier usually undertakes the task of maintaining the mine in a fit working state, or that it is the coal and not the mine which is to be rated.

The Superior Courts have recently held this system to be wrong, and that the Acts of 43 Elizabeth, cap. 2, and of 6 & 7 William IV., cap. 96, must be carried out in their entirety.

The annual average expenditure for repairs is, in a well managed concern, a question of fact which can be often ascertained from the colliery-books.

It is, however, necessary by independent surveys to consider whether

this expenditure is sufficient or extravagant, and expenditure in the nature of additions or extensions has to be eliminated as it is not part of the work of keeping the hereditament in a state of repair.

It has been shown that the "coal-mine" as described in the Act consists of the shafts, that is, the means of communication from the surface of the land to the underground workings, together with the roads for bringing the coal to the bottom of the shaft. These latter are laid with rails or tramlines, and the roof is, where necessary, supported by timber or steel girders, and they are, in fact, tunnels. In places—where the roof is very bad—the tunnels are actually formed of brickwork. There are also numerous airways for ventilation purposes. The roads and airways are constantly being lengthened as the working-face of the coal is removed farther away from the pit-bottom. Therefore, the hereditament continually becomes larger and more expensive to maintain. It is apparent that though as a matter of custom the repairing of the roads and airways and the maintenance of the tramlines are included by the occupier of the mine in his expenses, and the cost of this is usually thrown upon him by the covenants of the lease, yet they are expenses which, under the Act, are to be deducted from the gross estimated rental of the mine rather than from the gross receipts, as is the case with the ordinary working expenses of cutting and raising the coal. It is also apparent that the separation of these costs from the costs of actually getting the coal from the working-face and transporting it to the surface, is to a great extent a question of mine-administration and book-keeping, and that these costs will vary as the nature of the mines vary.

Until the Denaby Main colliery case was brought before the law-courts there had been no case tried which clearly elucidated the principles upon which a coal-mine should be rated. There were consequently no decisions to guide an Assessment Committee as to the manner in which an estimate of the rateable value of a coal-mine should be made.

This case arose out of the assessment of the well-known Denaby Main and Cadeby Main collieries, and was decided upon a case stated by the arbitrator at the request of the parties for the opinion of the High Court, in order that his decision might not afterwards be contested on any of the points set out in the case.

In order to arrive at an estimate of the rent which a yearly tenant would give for these collieries, the appellants sought to give evidence of the receipts, working expenses and the costs of maintenance. This

evidence was objected to by the respondents, who further contended that no deductions should be made from the gross estimated rental for the repairs, renewals and insurance of the mines, in order to arrive at their rateable values.

The Court decided in favour of the appellants on both these points, holding that, where the receipts and expenditure afforded the best means of arriving at an estimate of the rateable value, the accounts of the undertaking were admissible for the purpose, and that where it could be shown that there was any expense in maintaining, renewing and insuring the hereditament in order to keep it in such a state as to command the gross estimated rent then a proper deduction should be made from the gross estimated rental as set out in the rate, and that the statement in the rate as to this gross rent was conclusive evidence which the respondents were bound by and could not impugn.

This decision was given on April 5th, 1898, and the endeavour has been made to give due weight in this paper to the arguments and judgment.

Mr. G. C. GREENWELL (Duffield) wrote that Mr. Humphreys-Davies' paper explained very well the method and principles of which the adoption was attempted, but it did not appear to him to throw any new light on the mode of obtaining a satisfactory result, and such a result will not be attained so long as the "mineral" worked is taken as the subject of valuation. In 1865, he read a paper on the rating of coal-mines to the members of the North of England Institute of Mining and Mechanical Engineers* which fully recorded his views upon this subject, and they had not since changed. In that paper he advocated the rating of "mines," properly so called, and of those only, the quantities worked being the gauge of the importance of the occupation.

Mr. M. W. PARRINGTON (Sunderland) wrote that the subject of rating was of vital importance to owners of collieries, and was becoming more so year by year in proportion as local taxation was increased. He feared, however, that no paper read before this Institution, however ably written, would have the effect of removing the inequality of the rating of coal-mines as compared with that of other industries. Colliery-owners were largely to blame for this state of things. Their trade was one of

* *Trans.*, vol., xiv., page 93.

extreme fluctuations, and after the most extreme upward fluctuation on record, in the year 1873, they allowed the assessment of collieries, in a very large number of poor-law unions in the country, to be in many cases more than doubled. This did not at the time seem a very serious thing to owners whose collieries were situated in rural unions, as the Elementary Education and Local Government Acts had not yet had their effect on taxation, and a half-yearly rate of 1s. in the pound generally met local requirements. Local taxation was now becoming onerous in ordinary conditions of the coal-trade, and he feared that it would be found very difficult under the existing law to obtain any relief from such inequalities, of which he would give an example. A colliery, situated in the urban part of the union of Sunderland, and comprising the port of Sunderland, had been working for 65 years, entirely in two seams of coal, and necessarily the workings were now at an exceptional distance from the shafts. The gross drawings in 1898 were 632,000 tons of coal. The chief industry of the port of Sunderland was ship-building, and although no exceptionally large vessels were built, the aggregate tonnage of shipping turned out exceeded that of any other separate port, and in 1898 it was 262,673 tons. It was between these two industries that he would give an illustration of existing inequality in valuation for rating purposes. The valuers for the union were recently instructed to re-value the colliery and plant only, and their valuation exceeded that of the whole of the shipbuilding yards of the port, although the value of the shipping built could not be estimated at less than ten times that of the output of the colliery. The gross valuation was also nearly double the sum of the yearly royalty paid, although the principal lease of the colliery and nearly all the other leases were shown to be of recent date. In his opinion there was no remedy for such a state of things as he had endeavoured to describe under the existing vague condition of the law. It seemed absurd that the enormous sums of money necessary for the local administration of the country, collected from mine-owners, should be imposed under an Act passed in the reign of Queen Elizabeth. A general rating act was wanted, setting forth how each class of property should be valued, and what proportion of the rates it should bear.

Mr. W. Logan (Langley Park) wrote that he had read through this paper carefully, and while it was entirely in keeping with the author's previous paper on the same subject, it was admittedly written with a view of elucidating the decision in the Denaby Main and Cadeby Main colliery case, and to ask members to accept the ruling in that case as

being applicable to the future rating of coal-mines. His own impression, from a careful reading of the case, was that the judges referred to it as "an exceptional case," and thereby limited their decision to the Denaby Main and Cadeby Main collieries, but in this opinion he might be wrong.

Mr. Edward Boyle, Q.C., in a paper read before the Surveyors' Institution* in January, 1899, gave a clear illustration of how the decision in this case would be applied in practice, and while it might be technically and legally correct, he ventured to think that it would be found unworkable in the majority of the unions of the country wherein coal-mines were situate.

The paper by Mr. E. Boyle and that by Mr. Humphreys-Davies might be taken as being on the same lines; and their proposed foundation of the rating was to ascertain first the gross receipts from the sales of the coals, and from that certain deductions were to be made, which if less than the gross value would leave a sum to represent the rateable value of the mine.† This might be all very well in theory, but in practice he did not consider that it would be workable. It would require a very large number of experts to be constantly at work in a union wherein there were a number of coal-mines, and would thus constitute a large source of expense to the ratepayers. The variations in the rating would from year to year cover a wide range, and cause considerable fluctuations in the rate per £ to be paid by the other ratepayers. He did not think that a colliery-owner would care to disclose his profit when it was good any more than he would care to expose his loss when it was large.

It might be a fallacious system to arrive "at the gross estimated rental of coal-mines by ascertaining the quantity of coal worked in each parish,"‡ but an experience of over 20 years as a member of an Assessment Committee in a union wherein there were a large number of collieries led him to the conclusion that where it was carefully applied an equitable and just assessment could be arrived at. The variations in the conditions of the collieries in any one union were not so great that a scale could not be applied assessing the best and thickest coal at a maximum tonnage-rate, graduated downward to a minimum tonnage-rate for the poorest and thinnest seams, and still giving all due consideration to any special circumstances prevailing at

* *Transactions*, 1899, vol. xxxi., page 143.

† It is not, however, clear what would happen if the deductions were greater than the gross receipts. ‡ *Trans. Inst. M.E.*, vol. xviii., page 233.

any individual colliery. Where this was done the rates did not vary in the union except to the extent of an increase or decrease of the quantity of coal worked, and this in practice was not found to vary the rate in the £ to any greatly appreciable extent. There was no difficulty in obtaining from the coal-owner the quantity of coal worked every year, and having got that information the clerk to the Assessment Committee could in a few days, without an army of experts, produce a new and revised assessment. This method did take "account of a parish in which little or no coal is being worked,"* as it sustained a part of the assessment in proportion to the quantity of coal led through the parish, although the coal might have been mined in another parish. This method was of course subject to variations in its application, as the coal might be assessed at so much a ton, and the plant and machinery assessed at a lump sum in addition. His own opinion was that the assessment should be based alone on the quantity of coal worked, and that the plant and machinery should not be assessed, as they have no value except for the purpose of getting coal. He believed that he was right in saying that the same result would have been arrived at at Denaby Main and Cadeby Main collieries if the quantity of coal worked had been multiplied by 5d. a ton.

Mr. J. A. LONGDEN (Stanton-by-Dale) said that there was no doubt that colliery-owners were greatly indebted to Mr. Humphreys-Davies for his paper and to the Denaby Main Coal Company for the action taken in connexion with rating. But did Mr. Humphreys-Davies propose that colliery-owners should attend year by year before the Assessment Committee, and tell them whether they had had a good or a bad year with the intention of getting their rates adjusted. The method which Mr. Humphreys-Davies had condemned had been adopted for many years, and as far as he was concerned he hoped that it would still be in force for many years to come.

Mr. M. DEACON (Chesterfield) said that, for many years, he had taken great interest in the subject of Mr. Humphreys-Davies' paper, and in the main he agreed with that gentleman's deductions from a theoretical point of view, but from a practical point of view he hardly did so. The royalty principle was, on the whole, the most equitable basis that could be adopted, but it should be subject to variations which might occur in special cases. For instance, a mine, assessed on the royalty principle, which had a large quantity of water should be entitled

* *Trans. Inst. M.E.*, vol. xviii., page 234.

to an allowance, and in the same way, in the case of an old mine where the roadways were of great length and expensive to maintain, and as the quantity of coal coming out of such roads was reduced, a rebate should be allowed. But if they were to ascertain the rent payable by the hypothetical tenant for a mine, they could not take a better basis than the royalty one, subject to abatements. If such a general basis were not adopted, then they must submit to a separate valuation of every mine, which would be inconvenient to some owners, although it might prove of advantage to others. He himself would object to have his mines valued by a special valuation whenever it was thought necessary that the valuation should be revised. In 1874, a group of coal-mines in South Wales was assessed at 1s. 3d. per ton on the output, an appeal was lodged by the colliery-owners, but the rate was confirmed at Swansea Quarter Sessions. This case showed what might happen unless some steady and regular system of assessing the value of coal-mines were adopted. He might mention that, in the Sheffield union, both large and small coal was assessed at the same rate, which seemed to him hardly an equitable basis, because one colliery might have a tender coal and thus produce a large quantity of small, while at another colliery with a hard coal very little small would be produced. In South Wales, the system of assessing small coal at a less value than the large coal was in force, and this seemed to him a preferable system.

Mr. JOHN NEVIN (Mirfield) said that the last two paragraphs in Mr. Humphreys-Davies' paper were not in accordance with his recollection of the case. The court decided that the company should be assessed, not on the hypothetical rent, which had been the rule in the neighbourhood, but on the principle laid down in Mr. Humphreys-Davies' paper as to railways and canals, the Denaby case would not, however, rule the future. He thought that in South Yorkshire it had been the rule for the collieries to be rated on the rent which the hypothetical tenant was likely to give for the colliery. There was no doubt that this method acted adversely on some collieries, as in some cases proper deductions were not allowed; but he thought that if they were to adopt the principle of the Denaby case, and produce their accounts every year, it would be worse instead of better for them. Another point was that a district council liked to make an estimate of what their expenses would be, and they made their rate accordingly. If the coal-trade happened to be more depressed than usual and the profits were small, the rate would have to be increased or the district council would be in trouble before the end of the year.

Mr. A. Sopwith (Cannock) said that he had come to the conclusion that one must adopt some general system of rating and not enter into too great detail. It was impossible to rate a mine at the amount at which it would let from year to year, and it was a difficult matter to make a valuation for a certain length of time. In the case of a large single colliery in a union, if it were assessed in good times upon the rent paid by the hypothetical tenant, it would be assessed far too high when bad times came, and if the assessment were made in bad times it would be the reverse. Different systems were suitable for different districts, but there must be some rough-and-ready method of calculating how the assessment had to be determined, and he thought that in some cases the royalty-rent should be taken, and in others the selling price where there was a large number of collieries. In the case of a colliery working coal in different parishes, they should value the mine as a succession of tunnels, and make certain deductions. In the case of a colliery working all the coal from an adjoining parish, it became a difficult question to decide as to which union should receive the money: the parish in which the coal was worked, or the one in which the coal was drawn. The principle laid down in the paper would determine that point, but he wished to establish the view that it was perfectly impracticable to deal satisfactorily with individual cases or with different districts, and an uniform basis should be laid down, which could not vary in good or bad years. Also he thought that in a majority of cases the royalty-rent should be taken as the basis.

Mr. J. Barrowman (Hamilton) said that the difficulties stated by the author of the paper and those who had contributed to the discussion did not appear to him to be experienced in Scotland. The royalty in his opinion was a fair basis of valuation from year to year, because it was the result of an arrangement between landlord and tenant, carefully considered by each in his own interests, and made in view of the whole circumstances known or anticipated at the beginning of the lease. No doubt unforeseen difficulties were sometimes encountered which would materially affect the bargain made. In such cases, a readjustment was possible under the powers contained in most Scotch leases, by virtue of which there was a break in the tenant's option at intervals of a few years - usually three. If the coal-field was occupied by a satisfactory tenant, and the difficulties were of sufficient importance to warrant a change in the rate of royalty it was to the interest of both parties to agree on a reduced rate. This also applied to such cases as those indicated by Mr. Deacon.

Mr. A. DURY MITTON (Walkden) considered that three years was the usual period arranged between the Assessment Committee and the colliery-owners. He thought that the present system was very unsatisfactory, as the colliery-owner had no alternative but to apply to Quarter Sessions, if he considered that he was unfairly assessed. It would be better if the seams could be rated at certain fixed rateable values in all the districts upon a royalty-rent basis, and not adjusted from time to time so as to make up the deficiency of the funds for a district at the expense of the colliery-owner, without having any regard to the value of the different coal-seams.

Mr. SEP. H. HEDLEY (Sunderland) wrote that by the statute of the 43rd year of Elizabeth, coal-mines were made assessable to the poors' rate, and it had been decided by the Higher Courts that coal-mines being mentioned in the statute, all other mines were by implication excluded from assessment. Subsequent legislation (the Rating Act of 1874) had, however, made all other mines assessable to rates. Coal, like other minerals when severed from the mine, seam or vein from which they had been worked, was clearly stock-in-trade, and therefore the profits and losses arising from the sale of such coal when severed could not be considered, as it was immaterial whether the coal-mine be profitable to the owner or to the occupier, the occupier was liable to be rated. This was clearly laid down, not only in the old case of Rex *versus* Parrott (5 T.R., page 593), where a mine was worked at a loss and held to be rateable, but also by the more recent case of Regina *versus* Aylesford Union (26 L.T., page 618), where the parish officers sought to ascertain the profits of a chalk-pit for the purpose of assessment, but the Court of Quarter Sessions refused to allow the question to be put, on the ground that it was an enquiry into the profits of trade, and the Court of Queen's Bench decided that the Justices were right in disallowing the question. Mr. Justice Blackburn said that the rateable value of the chalk-pit was what a tenant would be likely to give who took the pit; and so it was with a coal-mine; it was the rent which a tenant would be likely to give that must determine the value, and not the profits made by selling the coal.

Originally no doubt the rent paid for coal-mines was fixed in the same way as lead, copper and tin-mines are still fixed, that is for a part or share of the produce of the mine, but the development of the coal-fields, and the experience acquired in working coal, has enabled the persons possessing coal-mines, and the persons working them, to ascertain their

local money-value, either to buy or sell, mortgage or let, with as much certainty as lands or other property.

In practice, collieries as a whole are rarely if ever let, the usual practice being to let the coal-mine, seam or vein on lease at royalty-rents per acre or per ton, the lessee agreeing to sink the shafts or drive the adits, and erect the buildings and plant.

In assessing collieries, the almost invariable practice was to take the quantity of coal worked during the year preceding the laying of the rate at so much per ton or per acre : to this was added the rent of the land on which the colliery was situated, *plus* a fair interest on the capital value of the shafts, surface buildings and plant. This was in effect carrying out the principle that every hereditament should be rated on its improved value irrespective of whether such improved value was made by the landlord or tenant, Rex *versus* Lord Granville (9 B. & C., page 188).

It must also be borne in mind that the great point to be aimed at in every rate was equality. This he considered would be absolutely impossible if collieries were assessed on the profit basis. It was a well-known fact that there were periods of great depression in the coal-trade, as there were also periods of inflated prices, and if the profit basis were adopted in years of depression some unions would lose thousands of pounds of assessable property—practically, collieries would go out of rating altogether—whereas in years of inflated prices they would be called upon to pay the greater part of the rates. This condition of affairs he was certain would give satisfaction neither to the rating authorities nor to the colliery-proprietors.

He contended that the true rule was a constant contribution which would at all times fall equally upon collieries and every other species of property.

If the principle advocated in Mr. Humphreys-Davies' paper were applied to collieries, there were certain to be very gross cases of inequality, besides the example stated above : take for instance, where two collieries (A and B) work the same seams of coal, similar quantities and under the same circumstances as regards markets and shipments. The A colliery, worked under skilful management, everything being done with efficiency, economy and energy, would yield a large profit ; while at the B colliery, worked by indifferent agents and with little or no energy, the profits are *nil*. If these collieries had been assessed on the profit basis, the A colliery would have been assessed at a large sum, while the B colliery would have been exempt. It must be borne in mind that the

managers of all collieries considered that they were working them to the greatest advantage, although the general opinion might be to the contrary.

Take another case, where two coal-companies (C and D) are competing for an area of coal in a township. The C company is worked at a loss, while the D company is worked at a profit, and their geographical position as regards the outlet for the produce of the mines is equal. The C company takes a lease of the coal at, say £300 per acre, although the D company was in a better position to give that price; and here again the C company would be exempt from rating in the township in which the coal was situate, if taken on the profit basis, and the township would be seriously damnified because it not only did not receive any contribution to its rates but the *corpus* was being exhausted, whereas if the D company had leased and worked the coal, the parish authorities would have received the rates due on this hereditament.

In the case of land, the rateable value was the amount of the average annual value of the land. It could not be said, where a farm was let, that the year's profit of each particular crop was to be taken into consideration in fixing the rate, and the value could not be ascertained by enquiring whether the property was more or less beneficial in a particular year. Suppose a farmer were able to prove that he was holding his farm at an assignable amount of loss, that would not constitute an exemption from the poor rate, Regina *versus* Vange (3 Q. B., page 242 ; 2 G. & D., page 476 ; 6 Jur., page 893).

In Rex *versus* Parrott (5 T. R., pages 593 to 596), where it was admitted that the lessee lost 2½ farthings on every ton of coal got, Justice Buller added to Lord Kenyon's judgment the following :—

If the property be rateable and the party rated be in the occupation of it, we cannot examine any further and enquire whether or not the tenant has made an unprofitable bargain.

It had been decided that "beneficial" and "profitable" in the ordinary sense of the words, were not convertible terms, and a party holding property in its nature rateable was not discharged from his legal liability to be rated because he did so at a loss.

In Fawcett *versus* Justices of Bombay (5 E. and F. Moo., page 143 ; 3 Moo. Indian Appeals, page 148), the Privy Council affirmed that an assessment of a manufactory upon profits was an assessment upon a wrong principle, and Vice-Chancellor Knight Bruce in delivering the judgment of that court said :—

If of two manufacturers in the same street carrying on precisely the same kind of business by means of fixed machinery, one makes an annual profit of £2,000 and the other a profit of only £1,000, that circumstance, if the respective buildings and machinery do not materially differ in size, description, or quality cannot render the one liable to be assessed at a higher rate than the other. The greater or less degree of success with which a trade or manufacture is conducted in a warehouse, manufactory, or other building having or not fixed machinery depends upon many various contingencies and cannot form a just ingredient in any calculation of its true annual value.

In the case of Regina *versus* Everist (10 Q. B., page 178), which was in respect of a brickyard, Lord Denman in his judgment said :—

But the next objection is a more important one, that it is altogether wrong in principle to consider the royalty as rent, and this appears to be founded mainly on this, that it is a sum paid not in respect of the renewing produce of the land, but of a portion of the land itself, and that not consumed by slow degrees and to be exhausted at the end of a long period, as is the case with a coal-mine, under which circumstances it was admitted that it might be treated as produce, but in such large proportions that the whole in a few years would be exhausted.

It does not appear to us that a more or less rapid consumption can make any difference in the principle. The rate is always imposed with reference to the existing value, whether temporary or enduring is immaterial. A case was supposed of a brickfield worked out in less than a year to meet the demand of some enormous contract for a public work ; the consequences would be that the land would have a very much increased value for the year, and it would be only reasonable that it should bear an increased rate for that year ; in the following year its value might sink almost to nothing, and the rate ought to fall proportionately, even to nothing, if the brickearth being exhausted, the land, like an exhausted coal-mine, should become entirely unproductive. If this were not so, an obvious injustice would be done to the ratepayers. Suppose two brickfields of the same size, which, if worked so as to be consumed in ten years and by equal working in each year would produce £1,000 each, on which the rate should be £10 : in ten years each will contribute £100 to the parochial authorities ; let one be exhausted in the first year, the produce will have been £10,000, but the rate only £10 for that year according to the appellant's argument, and it may be nothing afterwards ; but whatever it be afterwards, it is clear that there will have been a valuable occupation in one year, escaping as to nine-tenths the rate entirely. But no injustice would be done, if in every year the occupier could be assessed according to the actual value in that year, and it is the duty of the overseers to arrive as nearly at this as they can. . . . . . We come then to the bare objection that the royalty is paid not for the renewing produce of the land, but for the severed portions of the land itself, mixed up with foreign matter. The expense, however, must of course have been cast off before the royalty itself was fixed ; that was a sum which, after all such expenses paid, the occupier could afford to render to the landlord. When the case is thus laid bare there is no distinction between it and that of the lessee of coal-mines, of clay-pits, of slate-quarries ; in all these the occupation is only valuable by removal of portions of the soil, and whether the occupation is paid for in money or in kind is fixed beforehand by contract ; or measured afterwards by actual produce—it is equally in substance a rent ; it is the compensation which the occupier pays the landlord for that species of occupation which the contract between them allows. . . . .

We are brought, then, to the conclusion that the parish officers have done right in considering the royalty as a portion of the rent, and we see no objection to the mode by which they arrive *prima facie* at the conclusion that the amount of royalty reckoned in the rate will be paid in the year for which the rate is made.

In the case of Rex *versus* Attwood (6 B. and C., page 277), Abbot, Chief Justice, in giving judgment said :—

We are all of the opinion that the owner and occupier of a coal-mine should be rated at such a sum as it would let for, and no more. As to the other points, the first was that the rate should not be imposed upon the coal produced, because that was part of the realty. It is the first time such a proposition has ever been submitted, although many coal-mines in various parts of the country have constantly been rated, and the argument in support of it is wholly untenable. The legislature has expressly made coal-mines rateable, and they must be for what they produce, viz. :—the coal; slate-quarries and brickearth are also exhausted in a few years, but, nevertheless, the rate is always imposed upon that which is produced.

In Regina *versus* Aylesford Union (26 L. T., page 618) Justice Blackburn said :—

On the case stated I think we can have no doubt that the justices were right in disallowing the question. The rateable value of the chalk-pit is the value which a tenant would be expected to give for it. That value involves two elements, first, what would a tenant make by it, and what would a tenant get equally good chalk for in the neighbourhood? No tenant gives all he could afford to give, and the true test is not what he could afford to give, but what a tenant would be likely to give who took the pit from year to year. It is not the profits a man makes that makes the difference, for whether he gains or loses in his trade the rateable value is the same.

Justice Mellor said :—

I am of the same opinion. The criterion of rent is no doubt dependent to some extent on the amount of profit, but the proper test is not whether a tenant could afford to give more rent if he got more profit. The actual profits are not material. All that we are required to say here is whether the Quarter Sessions were right in the test they applied, and I think they were right.

In Dodds *versus* South Shields Union Assessment Committee (59 J. P., pages 87 and 452; 72 L. T. Q. B. D., page 55; L. R., page 1895, 2 Q. B., page 133), Lord Esher in delivering judgment said :—

The rent which the ordinary tenant would be willing to pay is the rent which could be got for the premises in the house market. That is the general rule; and I agree with Mr. Justice Wills that in ascertaining the rateable value of the premises under the Parochial Assessment Act, 1836, the question of the profits made by the tenant, or of his gross receipts, asked for the purpose of arriving at the profits, though not immaterial if the point to be determined were what the tenant could afford to pay for the premises, is (that not being the question to be determined) wholly immaterial and what is more mischievous oppressive and unfair, and should be rejected in all cases where the ordinary evidence of value can be obtained.

And Lord Justice Smith said—

It is *nihil ad rem* whether the particular tenant has made or lost so much a year out of the premises. Suppose that, instead of making a profit, he has lost money by the premises, are they on that account to be rated at nothing? According to the hypothesis, the fact that the tenant has lost money by the premises is evidence that the premises ought to be rated at nothing. The profits made by the tenant have nothing to do with the question of the rateable value of the premises.

It appears therefore that a valuation on receipts and expenditure was only correct in the case of public companies and properties incapable of comparison with other similar properties which are let.

On the question of profits, the following cases may be referred to. In Rex *versus* Hull Dock Company (5 M. and S., page 394) where at the time the rate was made the company made no profit in consequence of certain rebuilding operations, Lord Ellenborough said—

There is no question as to the rateability of this property; it has very properly been admitted that it is rateable. The question therefore is, whether a rate can be imposed in respect of property which is generally rateable, but the profits of which, owing to certain incidental and necessary expenses, have been for a time exhausted. As to which it is to be observed, that a rate is not always imposed on property in the particular year in which it makes a productive return. . . . . To hold that in every case where property is rateable, an account is to be taken for the particular period for which the rate is imposed, of the precise amount of its productiveness, and that if there is the smallest decrease, the rate is to be reduced *pro tanto*, would in my judgment be infinitely inconvenient. . . . It appears to me that this rate is well imposed, and that the average profits of the company are not liable to be merged in the partial expenditure of any particular period.

In what is known as the Denaby case, the learned arbitrator found that the Denaby and Cadeby collieries were exceptional collieries, and his finding was as follows:—

There being no collieries let from year to year, there are no means of comparing the appellants' collieries with others for the purpose of ascertaining what a tenant would give from year to year.

Mr. Justice Day, in delivering judgment, said that:—

This is an exceptional case. There is nothing he says, and so far as I can imagine, he would say with which he could compare it. He knows that no collieries are let by the year, and I suppose no one has ever yet heard of a colliery being let by the year. It is clearly an exceptional case to be dealt with exceptionally, and to be dealt with in the mode which he suggests himself, and in the way which he considers a practical way. These rating questions are to be determined as nearly as possible correctly, and, therefore, of course, in the most practical way that is available. It seems to me that this is a proper way of dealing with it.

And Mr. Justice Phillimore said :—

I am of the samé opinion. I think it must be taken from the findings of the arbitrator that this colliery is such an exceptional colliery, that the assessment can only be arrived at by the method applied to what are called exceptional cases; and, therefore, the evidence put forward by the appellants is necessarily admissible.

Referring again to the arbitrator's finding in the Denaby case, that no collieries were let from year to year, this would apply to nearly every description of large properties, namely: blast-furnaces, steel-works, chemical-works, engineering-works, etc. No tenant would take any of the above-named properties on a year-to-year tenancy, therefore, if the principle suggested has to be carried out in its entirety, which it would be necessary to do to arrive at a rate on an equal basis throughout, one must enquire into the profits of all these undertakings. This was never the intention of the legislature, and from the cases quoted it would be seen that the judges had always strongly opposed enquiry into the profits of a man's business.

In conclusion, he would draw the attention of the members to what has been termed the "royalty-rent system of rating;" this had been described by some as a rough-and-ready method of assessing collieries, but from the very few cases that have been contested during the last 50 years he thought that he was justified in saying that it had worked in a most satisfactory manner. It was impossible, however, to lay down any rule that would give absolute satisfaction to all parties. You must have a law that would suit the majority, and this you had in the royalty-rent basis. In proof of his contention he would refer the members to the Rating Act of 1874, which brought into rating all mines exempt under the Act of 43rd Elizabeth, and included the ironstone-mines of Cleveland, where the mineral lies in the same stratified form as in coal-mines and is worked in a similar manner. The section reads as follows :—

In the case of any other such mine which is not excepted from the provisions of this Act, and to which the foregoing provisions of this section do not apply: [viz., copper, lead and tin], the gross and rateable annual value of the mine shall be taken to be the annual amount of the dues or dues and rent at which the mine might be reasonably expected to let, without fine, on a lease of the ordinary duration, according to the usage of the country, if the tenant undertook to pay all tenant's rates and taxes and tithe rent-charge, and also the repairs, insurance and other expenses necessary to maintain the mine in a state to command such annual amount of dues or dues and rent.

The most important part of the section quoted was that which stated that the rent had to be taken on the basis of a lease of ordinary duration

according to the usage of the country; the legislature, no doubt, having in view that it would be an absolute absurdity to take it on a year-to-year basis, when no such condition of things existed, and colliery-owners had accepted this common-sense view of the royalty-rent basis.

Mr. G. HUMPHREYS-DAVIES, replying to the discussion, said that the question of rating was an extremely intricate one, and lawyers would tell them that it was most technical, and that when applied to coal-mines it was still more difficult. The observations made in the paper as to the principle of assessing the coal itself had been rather overlooked. No doubt by custom extending over a long number of years it had come to be taken that it was the ton of coal taken out of the mine that was rated, but it had been proved almost conclusively that that was not so. The coal itself lying in the seam or not broken off by the miner was not rateable, but the royalty system seemed to him to imply that the coal was rateable. The question, however, had not yet been settled, but he was engaged in a case which would probably go to the House of Lords, which would settle that very point beyond all doubt. The Act of Elizabeth said that the "coal-mine" and not the "coal" was rateable, and therefore the rate should be made upon the rent, which the hypothetical tenant would willingly pay for the right to use the road along which his coal was conveyed. But the difficulty lies in solving how much he should pay. A valuation, based upon the actual result at each mine, was, after all, the best method for arriving at an answer. It was an hypothetical solution, but it had been applied satisfactorily in the cases of railways, waterworks, gas-works, docks, etc., and he (Mr. Humphreys-Davies) did not see why it should not be applied to mines. By the Denaby case it was decided that the best method of arriving at the hypothetical rent which the tenant could pay was to find this out from the actual results of the working. If a better method could be discovered or if by looking at the state of the roads and estimating so much per foot or per mile, or by intuition the rent could be arrived at, well and good. But there was this point to be considered: it was not the value of one mine that had to be assessed; and they had in a parish sometimes 1, sometimes 20 mines; but there were also the farms, factories, shops, etc., and the law says that the rate must be apportioned equally amongst them all. It would be unfair to colliery-proprietors to assess them too high, and unfair to the others to assess them too low. There must be equality at the time when the rate was made, and not an average of equality for 10 or 20 years. He did not see how they were

going to make allowances for the difference in the selling price of the coal, working expenses, etc., unless they did something more than fix an arbitrary sum. There must be equality between all ratepayers at the time when the rate was made; there must not be an average rate over a term of years, or there would be unfairness. As to the difficulties of assessment committees, he would remind the members that railways, waterworks, gas-works, electric and other undertakings were larger in extent and in value than mines—large and valuable as they were—and they had to be rated, and the number of appeals resulting from the rating of these properties was very small. From his own experience (and it was not small) he could say that the rule was that 999 out of every 1,000 cases accepted the assessment, and in the case of railways the rating was settled without much difficulty. It was only at the last extremity that one was forced to go into the question of accounts, as in the case of the Denaby Coal Company, and the assessment of coal-mines could be settled with little difficulty, so long as the parties agreed as to the system upon which the assessment should be made.

The PRESIDENT (Mr. H. C. Peake) proposed a vote of thanks to Mr. Humphreys-Davies for his valuable and instructive paper, and he thought that the discussion which had taken place upon it had also been very instructive.

The vote of thanks was carried by acclamation.

Mr. JOHN GERRARD read the following paper on "Instantaneous Outbursts of Fire-damp and Coal, Broad Oak Colliery:"—

INSTANTANEOUS OUTBURSTS OF FIRE-DAMP AND COAL, BROAD OAK COLLIERY.

By JOHN GERRARD, H.M. Inspector of Mines.

From May, 1885, to March, 1893, a number of outbursts of fire-damp and soft coal occurred at Broad Oak colliery, Ashton-under-Lyne, Lancashire, some of which caused loss of life, while some of the others narrowly escaped fatal results. For 8 years all persons connected with the colliery were anxiously concerned as to how these occurred, and what precautionary measures should be adopted for their prevention or to avoid danger to life.

Having personally investigated several of the outbursts and shared the anxiety of those connected with the colliery, the writer, in compliance with request and with the full concurrence of the owners, proposes to place on record some of the facts associated with the outbursts, and to describe the measures adopted for their prevention and the present mode of working.

The Nook pits of the Broad Oak colliery won the Royley coal-seam about 1870, at a depth of 888 feet. This seam is the lowest in the Middle Coal-measures of the Ashton and Oldham districts. The seam dips to the west. From the outcrop to about 1,500 feet to the dip of the shaft, it is 27 degrees, or 1 in 2; below that point it gradually decreases, being now, at 3,090 feet below the shaft, 19 degrees, or 1 in 3. The Royley seam consists of 2 feet of good coal, with 1½ feet of soft, impure, inferior coal above. This latter portion was holed some 2 feet in advance of the lower portion, hence the local appellation "minings."

The coal to the rise of the shaft was worked out and an engine-brow was then driven in a slanting direction, some degrees to the north of the full dip. Pillars of coal were left between the brows, 18 feet wide and 24 to 48 feet long. Four ranks from four levels had been opened, and pillars of coal were left on each side of the brow, from 180 to 240 feet in width.

In working the rise-coal and three of the level ranks to the dip there were no outbursts, although fire-damp was given off freely. There were

frequent gob-fires caused by the inferior coal stowed in the waste, the soft inferior coal containing iron-pyrites in nodules and otherwise disseminated throughout the bed.

The outbursts began when about 1,500 feet of depth had been attained. The first recorded outburst occurred in May, 1885, in No. 4 north level, at 480 feet from the engine-brow. Fire-damp was given off, and the bed of soft coal disturbed for 16 feet in advance of the face, and a large quantity of the coal was expelled into the working-place.

In October, 1885, in the same level, 840 feet from the engine-brow, a much more serious outburst occurred, causing the abandonment of the working-place for a time, and thoughts were entertained of abandoning the mine. Two years afterwards, driving out was resumed, and almost immediately outbursts followed, chiefly on the south side.

In No. 4 south level, at 432 feet from the engine-brow, a series of outbursts occurred in 1888, namely:—May 1st, May 10th, June 11th, June 15th, June 25th, in both day and night shift, and June 27th. Some of these outbursts were small, and others large in extent.

In the north level, at 1,200 feet from the engine-brow, on August 12th, 1888, a small outburst occurred in a narrow place, and on August 28th another one. All these occurred when men were working in the places, sometimes the men were caught and partially buried, and at other times they escaped with difficulty.

In 1890, another rank was won by further driving the engine-brow to the dip. While so driving one of the brows, 5 feet in width, on May 2nd, 1890, the soft coal shot up into the brow when two men were at work: one man was smothered, and the other man was so stuck fast as to require liberating by the fireman, who visited the place while going his round.

On July 22nd, 1890, another fatality was caused by an outburst from the face of a narrow place being driven to the rise of No. 5 north level, at about 177 feet from the engine-brow. The miner was driven against a prop and found smothered under the small coal. It was stated that a hole was being bored by the deceased when the outburst occurred; that the hole was in the soft, upper coal, about the middle of the face, and that the hole was 5 feet in advance of the face and 2 inches in diameter. This was the first case in which any attempt at boring was associated with an outburst.

Following these outbursts, up to July, 1891, ten outbursts are recorded, all on the No. 5 south level:—

On November 20th, 1890.

On November 28th, at about 420 feet from the engine-brow, the level being 30 feet wide, the discharge occurred in the high side corner, a hole made by a 2 inches drill was said to have been bored 9½ feet in advance of the face and about 5 feet from the side of the outburst; all lights were extinguished, and the men narrowly escaped.

On January 19th, 1891, from the higher side corner of the face of the level, 30 feet wide, gas blew off like steam, at 5 p.m. it filled the place and the higher side for 90 feet back to the opening, and all was reported clear at 9 p.m.

On February 3rd, 1891, in an outburst in the high side corner of level face, 30 feet wide, 2 out of the 3 men were buried by the coal but got out. It occurred at 6·15 p.m.; a large quantity of gas was given off, and the place was clear at 7·30 p.m.

On March 9th, 1891, an outburst occurred in the corner of a place 30 feet wide, to the rise of the level. A man had bored a hole in the lower part of the seam, 5 feet in, and the hole penetrated the upper part of the seam; when the man was about to measure the hole an outburst occurred, he was knocked down and covered with the small coal, but got free and escaped.

On March 31st, 1891, a small outburst occurred in the high side corner of face of the counter level, 30 feet wide, and a bore-hole in the lower coal 5¾ feet in advance was left intact

On April 23rd, 1891, a small outburst occurred in the high side of the level face, 30 feet wide; a hole made in the lower coal, 11 feet in advance, was stated to have been bored in the middle of the outburst.

On July 10th, 1891, a small outburst occurred in the lower side corner of the level face, 30 feet wide; a hole is said to have been bored 11 feet in advance in the extreme high side corner.

On July 16th, 1891, a small outburst occurred in the rise side of the counter level, 30 feet wide; a hole is said to have been bored in the face, 9 feet 10 inches in advance.

On July 28th, 1891, a small outburst occurred in the face of the level, 30 feet wide, in the high side. It was stated that a hole was bored 6 feet in advance, at 6 feet from the high side, and another hole 12 feet in advance, at 9 feet farther off from the high side. No warning was given, and the coal burst out with a sound like a number of rifle-shots.

In 1892, the engine-brow was extended to win another rank, while driving a narrow place 6 feet wide from the main engine-brow towards the back brow, on July 21st the miner (Alexander Cross) noticed that the upper soft coal began to "boil out"; he moved away, immediately a large quantity of fire-damp issued and small coal was blown out into the place, but Cross being fastened by the leg was not able to get away. Subsequently a hole was bored in the face, a pressure-gauge fixed, and the highest pressure recorded was 14½ lbs. per square inch.

On October 1st, 1892, another fatal outburst occurred in a place 5½ feet wide, being driven to the rise of an opening from the main engine-brow, at a point 387 feet below the No. 5 levels (Fig. 2, Plate VIII.). The collier (Alexander Cross) who so narrowly escaped in the last outburst, was in this case smothered by the fire-damp and small coal. At the inquest, the son of deceased stated that they commenced work about 11 p.m. on September 30th, about 2·30 a.m. following, the fireman on his visit was told by the deceased that the "minings" were very "wick," and they kept cracking. The fireman told them to be very careful. After getting up and filling the bottom coal, deceased wanted to begin another holing in the "minings" or upper, soft coal; he struck a blow or two with the pick, and then ran back and listened; the "minings" were very "wick." He returned to the face, struck a few more blows, then ran back 12 feet. When quiet he went again and was striking with the pick, there was a low noise, deceased ran shouting "come on," then there was a loud report like thunder, deceased fell and was covered by the expelled small coal. He was found 12 feet from the face, lying full length with his cap held over his mouth. In this case, the fine coal was projected 25 feet from the face, the area disturbed being 16 feet wide, and about 20 feet beyond the face. About 22 tons of loose, small, very dusty coal were filled from the place. These facts point to there being ample warning of impending danger. There was no bore-hole in the face.

On January 31st, 1893, another fatal outburst occurred, about 10·40 a.m., in the face of No. 6 south level, 123 feet from the engine-brow (Figs. 3 and 4, Plate VIII.). The level was driven 36 feet wide, and 5 men were at work, 3 holing in the upper part of the seam, the "minings" of the soft coal; and 2 men were engaged in getting the bottom coal. There was a sudden cracking noise, immediately 3 of the 5 men were overwhelmed with the expelled small coal and fire-damp. Brattice was erected in order to remove the gas, the small coal was filled into tubs, and it took almost 2 hours to recover the first body. About 20

tons were filled into 72 tubs, of the fine, crushed, loosened coal. One of the survivors stated that hearing the cracking, he shouted to his mates "come on," and ran for his life. After going 10 or 15 feet, looking round he saw his lamp, which he had left hung on a prop, was extinguished, then he felt gas which smelt very strong. From starting work at 6·30 a.m., everything had been perfectly quiet, there was no cracking, the "minings" were not "wick," and the workmen had not received the slightest warning of impending danger. The only remark made was by one of the deceased, who said that the "minings" looked "blacker and shinier." One lift of 2 feet had been taken right across the face, and they had just started to hole for another 2 feet lift. The under-manager passed through the place, 25 minutes before the outburst, and made a thorough examination, there was not a single "fizzer" of gas, not a rap or a crack, and the "minings" were not working. There were no bore-holes in this place, and none had been bored for some time. There would be over 1,800 feet of cover on the seam at this point.

It was observed, in connexion with this outburst, that the "minings" or upper portion of the seam had contained much hard fireclay. The expelled quantity was almost free from this; it was nearly all coal, very friable, and having shining black faces. The deceased had just holed into this changed area.

The last outburst occurred on March 9th, 1893, at about 12·20 noon, from the face of No. 6 north level, 225 feet from the engine-brow. The level was driven 51 feet wide. There was a bore-hole in the "minings" 6½ feet in advance of the face, 2¼ inches in diameter, and 3½ feet from the lower side. Two men were at work; the cracking coal gave them a slight warning, they ran away, and one of them looking round saw the coal coming towards him like a "wave." About 45 tubs were filled from the disturbed area. The manager had carefully examined the place ½ hour before, at 11·50 a.m.; he saw the hole bored 6½ feet: a little gas was given off from the hole, and from the face generally gas exuded, showing a cap on the safety-lamp. The manager noticed that the "minings" were very coaly, and the absence of fire-clay (Fig. 5, Plate VIII.).

The writer examined this place 6 hours after the outburst, and before anything was removed. Fire-damp was then found to be issuing. There was not the slightest indication of any heat, the temperature being 70° Fahr. He proved that there was no cavity, and that there was an area disturbed; the coal was broken up into small pieces, but

among the expelled portion there were several large lumps : one piece measured 33 inches in diameter and 2 to 3 inches in thickness. The expelled coal extended over the lower road for a distance of 20 feet from the face, and at 10 feet from the face the coal nearly reached up to the roof.

From this record it will be seen that outbursts occurred in narrow places, 4 to 6 feet wide ; and in comparatively wide places, 30 to 50 feet wide. That they all occurred in opening out while cutting into the solid coal. There were no outbursts while working out the coal in the pillars.

As regards bore-holes, the changes have been rung from (1) none at first; (2) to bore-holes in the upper part of the seam (the "minings"); (3) to bore-holes in the lower part of the seam ; (4) boring abandoned; and finally (5) an extended systematic boring in the "minings." When boring was commenced it was thought that a small hole would suffice to let off the gas. The diameter of the hole was then 1 inch, and it was thought that one hole bored in a suspicious part of the place would be sufficient. The boring of the holes by contract, at so much per foot, by the collier, did not answer.

An attempt was made to keep the holes 12 to 15 feet in advance, but it was not possible, as the holes became closed, leaving only 7 to 9 feet open. Later an attempt was made to bore them 10 feet long, but as it took as long to bore the last foot as the first 9 feet, it resolved itself into 9 feet holes.

The borers frequently had alarming experiences. In one case, the manager, fireman and a collier were putting in a hole When 5 feet in, there was a crack like a shot; they all ran back 15 or 20 feet. Returning in 2 or 3 minutes, they tried the hole and found gas issuing. They then resumed boring; for 1 foot the "minings" were very soft, the issuing gas made a noise like steam, the scraper choked up, and on loosening it a handful of dust was blown into the man's face.

In another case, when the hole was 7 feet in, raps began, and work was stopped awhile; on resuming work the raps recommenced, there were 12 or 14, like guns going off. The fireman was in the act of trying for gas when he heard a peculiar noise, like a grunt, and the safety-lamp was filled with gas in an instant.

In another case, all was quiet before beginnning to bore, the "minings" were a little "set" and clayey at the front. When the hole was 3 feet in the "minings," the bottom coal began to crack and

work, and gas was given off from the hole freely. It was so abundant that the men were withdrawn for ½ hour. On resuming work, at a depth of 4½ feet, the cracking again began, and the whole face, 15 feet in width, sounded as if it would blow out. The hole was stopped, and the men withdrawn. The next morning the hole was bored to a depth of 9 feet, all was quiet and no gas apparently was being given off; but when the colliers took off 3 feet of "minings" gas began to issue from the bore-hole with a loud blowing noise. At the commencement of this hole, it should be observed, the boring was very stiff, as hard clay prevailed, but the stratum became very soft at the end of the hole.

Several times, it has been proved that the outbursts were coincident with a marked change in the upper stratum of the coal-seam—from containing much hard fire-clay to being almost all coal. The coal was extremely friable and could be easily crushed in the hand, and apparently the gas was impounded within the areas of friable coal.

Towards the end of 1894, when it was again desired to extend the engine-brow, with the view to winning another rank, it was with difficulty that the men could be found willing to work the place—only one set of 6 men were found willing.

It was decided to carry 3 bore-holes in advance, one in the middle and one near each side of the place, driven not less than 45 feet wide. The front holes were to be bored 9 feet in advance, and when 4 feet of face was removed the holes were to be carried forward to 9 feet, or fresh holes bored 9 feet deep. Flank holes on each side were to be bored 7 feet deep, and at intervals of 4 feet. All the holes were to be bored by a 3 inches drill by daywagemen. One man was specially appointed, who was to employ one of the colliers as an assistant. All the "minings" were to be filled into tubs and sent out of the pit.

It was further decided to open out wide places from the sides of the engine-brow as soon as practicable, and to leave no pillars of coal, the object sought being to give every opportunity for draining the gas from the seam.

This system has admirably succeeded, and not a single outburst has occurred for over 6 years. The engine-brow has been extended nearly 900 feet, and is now in course of further extension.

The conditions now—as regards the "minings" being coaly, soft, fireclay interspersed periodically, gas being freely given off, pyrites present—are as near as possible the same as when the outbursts occurred. The cover has increased until now it is about 2,100 feet.

It should also be observed that with the present mode of opening out there have been no gob-fires; on occasions the packs have been found heated, but there being ample facilities for examination the packs can be got at readily, and the heated portions removed. Under the old system the roads were often inaccessible, and, if necessary, new roads had to be made to deal with the heated places or fires.

Where the coal is entirely removed, the engine-brow, when once settled, requires very little timber and little repair. The part of the engine-brow where coal-pillars were left required timbering, and the bars were being constantly changed.

The following is a chemical analysis of the "minings":—

Samples.	No. 1.	No. 2.	No. 3.	No. 4.
Fixed carbon	46·71	12·25	43·50	0·97
Volatile matter	17·97	17·03	17·69	6·82
*Mineral matter	20·47	47·83	24·87	89·58
†Sulphur (which burns away) ...	13·81	22·08	13·10	0·94
Moisture	1·04	0·81	0·84	1·69
	100·00	100·00	100·00	100·00
*The mineral matter contained sulphur	trace.	0·14	0·41	trace.
†Sulphur, equal to iron pyrites, FeS_2	25·89	41·40	24·56	1·76

The accompanying plans (Plate VIII.) show the form of the workings during the period of outbursts, the position of those recorded, the disturbed areas in several cases, and the form of the workings in the present mode of opening out.

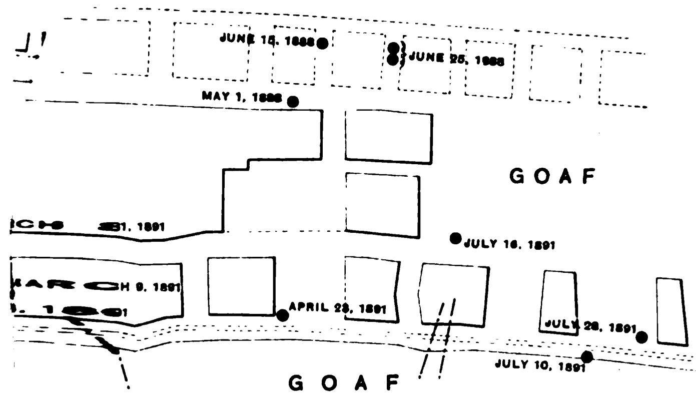
Specimens of the various strata of the seam were exhibited.

Mr. H. W. HALBAUM (Gateshead) wrote that Mr. Gerrard's record of the phenomena at Broad Oak colliery and of the means which had been successful in reducing those phenomena went far to fortify the position of those few mining-engineers who maintained that bumps and outbursts of coal were due to the pressure of gases *in situ*. He (Mr. Halbaum) had some time ago formulated a theory as to the cause of, and the coincident phenomena associated with, such outbursts of coal, and the paper written by Mr. Gerrard formed so remarkable a testimony to the soundness of the theory that he thought he might be permitted to submit a recapitulation of the main points. The Broad Oak colliery was not the only mine in which such outbursts of coal had occurred, and a perusal of the *Transactions* showed that mining-engineers were not by

Fig. 1.—BROAD OAK COLLIERY.

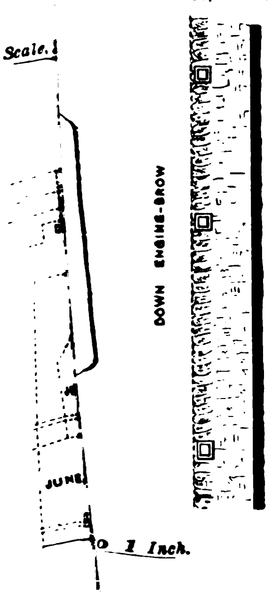
Plan of Workings in Royley Mine.

● OUTBURSTS OF FIRE-DAMP AND MININGS.



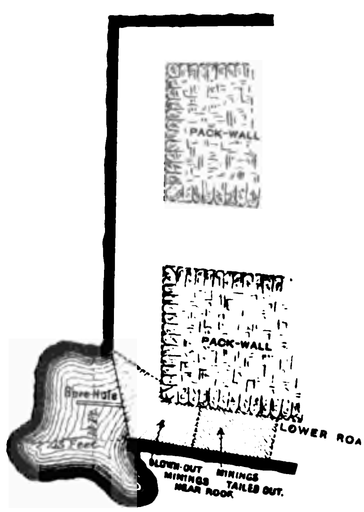
TOBER 1st, 1892.

Scale, 1



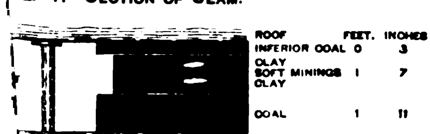
o 1 Inch.

Fig. 5.—Plan of Outburst on March 9th, 1893.



Scale, 24 Feet to 1 Inch.

ig. 4.—Section of Seam.



Scale, 8 Feet to 1 Inch.

any means agreed that gaseous pressure was the chief factor; while some engineers had even stated that, in their opinion, gas had nothing whatever to do with the matter. The complete success of the remedial means adopted at the Broad Oak colliery, however, showed that, in this case, at least, gas had a very great deal to do with such occurrences. The general theory of the case for gaseous pressure covered a large area of ground, but the main points might be summarized as follows:—(1) Other things being equal, it was reasonable to think that the quantity of gas generated in the unit of time in a seam would vary directly as the chemical activities in that seam and directly as the thickness of the seam. (2) The pressure of gas *in situ* must vary inversely as the facilities for its escape, or in other words, the pressure varied as the depth of the seam, and inversely as the porosity of the strata. By the depth of the seam, he meant the depth below the drainage-level, and it would be understood that this drainage-level might be the natural drainage-level, or an artificial one, such as a worked-out, or opened-out upper seam. (3) An area of face being exposed, theory and practice alike pointed to the conclusion that the pressure of gas *in situ* varied as the square root of the distance from the exposed area. The exposed area of face was, of course, an area of outlet. (4) In homogeneous coal, the curve of pressures which, by (3), was a parabola, extended from the face into the solid coal; the vertex of the parabola was at the face of the coal and the zero of the pressures. The curve of the pressures being continually extended into the solid coal merged, at some point indefinitely distant from the face into the ultimate straight and horizontal line of the original pressure *in situ*. By the term "original pressure *in situ*," he meant the pressure obtaining before the seam was tapped. (5) In disturbed areas, the seam may be anything but homogeneous, and ribs of coal materially differing in general structure, etc., might be successively met with. In such a case, the curve of pressures became a composite curve formed of the various parabolic curves peculiar to the respective porosities of the respective ribs whose respective structures, etc., were dissimilar. And in such cases, the zero of the curve for each successive rib stood on the ultimate ordinate of the curve of pressure for the rib preceding. And this meant that behind each of the less porous ribs the pressure was, so to speak, banked-up in abnormal quantities. (6) By the properties of the parabola, every curve of pressure was necessarily and invariably steepest at that end which was nearest the face. (7) Since the porosity was greater along the lines of cleavage than across them, the curves of pressure crossing the cleavage

were steeper than the curves whose axes ran in, or were parallel to such lines of cleavage. (8) As the face of work advanced, the curve of pressures retreated and continually endeavoured so to readjust itself that the zero of the curve was at the face of work. (9) Where the steeper curves of pressure obtained, the face might advance more quickly than the curve could, by means of the porosity alone, re-adjust itself to its true geometrical shape without more or less violence. This meant that the readjustment of pressure would be accompanied by phenomena of more or less violence, which might be exhibited in any degree, from a mere crackling in the holing or kirving to small "bumps," such as those experienced at several collieries, and up to the violent "bumps" and outbursts of coal such as those recorded at Broad Oak, Hamstead, and a few other collieries. The dissimilarity of these phenomena was not due to any material difference in their nature, but was due to the degree of force behind them. (10) The faces of work most liable (by his theory) to overtake the curves of pressure and to set up violent phenomena were (*a*) the faces of such drivings as were being carried across the planes of cleavage; (*b*) the faces of the narrower drivings; (*c*) the faces of drivings whose height was less than that of the seam; (*d*) the faces of drivings in those ribs of lesser porosity, behind which the pressure was banked-up in abnormally large quantities. For all of these were cases where the curve of pressure was liable to be unusually steep at the face. (11) Violent re-adjustments of the pressure-curve consisted (as might be shown easily did space permit) of a series of strictly progressive phenomena, each of which in turn gave rise to that immediately succeeding, and each of which was accompanied by an explosive report, the succession of phenomena producing a succession of reports which might vary in loudness from a series of cracks in the holing to a series of thunder-like reverberations, according to the violence of the re-adjustment. (12) Gaseous pressure in the coal existed in every pore of the coal, hence, in all outbursts of coal due to purely gaseous pressure, the coal was likely to be considerably pulverized owing to the fact that the explosive force producing the outburst was a force which pressed outward from every pore, and so tended to burst every pore. By such outbursts due to such a cause men were more likely to be smothered than crushed. (13) Where the pressure *in situ* was abnormally high, it was natural to suppose that the temperature obtaining in a bore-hole would be less than that of the outside atmosphere; because the bore-hole was the exhaust-chamber which received the gas exuded under a high pressure, and the temperature of this exhaust-chamber would be

less than that of the atmosphere of the mine owing to the absorbtion by the expanding gas of heat from the atmosphere in the bore-hole. The same thing was seen in connexion with the exhaust of an engine driven by compressed air, and the same thing appeared to obtain at Hamstead colliery where it was stated that the temperature of the strata was apparently less than that of the atmosphere of the mine. If the temperature of the strata at Hamstead colliery was really less than that of the mine air, it would be interesting to learn what maintained the mine air at this superior temperature. But this theory of gaseous pressure appeared to show clearly that this difference was only apparent and not real, while the same theory gave a natural explanation of the Hamstead bumps. These did not, unfortunately, owing to the immense height of the seam, appear to be remediable by exactly the same process as that which had been so signally successful at Broad Oak. But (14) the obvious lesson of this theory was the enlargement of the face-area. The outbursts were due to the face advancing too rapidly upon the pressure-curve. By enlarging the face, its advance on the curve was retarded, and at the same time, owing to the enlargement of the area of outlet, the steepness of the curve itself was reduced. He had, perhaps, put the case for the theory of gaseous pressure rather too briefly for complete lucidity, but he submitted that the theory was well worth the consideration of those who had to deal with occurrences so distressing as those associated with the history of Broad Oak and Hamstead collieries; and he thought that Mr. Gerrard's paper practically established the theory, so far, at least, as Broad Oak colliery was concerned.

Mr. H. F. Bulman wrote that instantaneous outbursts of fire-damp and coal, such as those described by Mr. Gerrard, had occurred within recent years at the Metropolitan colliery, near Helensburgh, some distance to the south of Sydney, New South Wales. The following particulars were gathered from Mr. Daniel A. W. Robertson, the manager, during a visit paid to the colliery last year. The Main coal-seam lies at a depth of 1,100 feet at the shafts, and there are no other seams above it. It is 11½ feet thick, including some inches of stone bands, but the lower 4 feet 8 inches are of inferior quality, and are only removed to make height in the mainroads. The upper 6 feet is a good steam-coal, containing a higher percentage of carbon than most Australian coals. Above it comes 4 feet of grey shale and then sandstone. It is a heavy coal, having a specific gravity of 1·3. The seam is of a jointy nature, containing numerous backs and vertical partings,

which make it easy to hew. A hewer works 5 to 6 tons in his 8 hours' shift, without the aid of any explosive. It makes a great deal of gas. In the main return airway a Clowes lamp indicated regularly 1½ per cent. of gas, and on one occasion when the fan was run at half speed for 3 hours the percentage of gas in the return-air was doubled, that is, raised to 3 per cent. during this time. The mine is very dry, dusty, and hot, the temperature being as high as 78° Fahr. A Walker fan, 20 feet in diameter, produces a current of air of 300,000 cubic feet per minute. The seam is worked on the double-stall system: the headings, 12 feet wide, are driven in pairs, and on each side, stalls, 30 feet wide, are turned away. The pillars between the stalls are 150 feet wide, except every third pillar, which is left double this width, or 300 feet. Accidents from falls of coal in the face are numerous, due to the jointy structure of the seam, the strong pressure of escaping gas, and the considerable top pressure, the cover being 1,600 feet thick in places. Loud reports and cracks (known in Staffordshire as "bumps") are common.

During the last three years, six sudden outbursts of gas, carrying with them a lot of solid material, have occurred. The worst of them killed 3 men (2 hewers and 1 putter), who were smothered before they could escape. This accident occurred in a heading, 12 feet wide, and the solid material, which was dirty, disintegrated coal of "duff" size, filled the place 5½ feet high for a distance of about 100 feet back from the face. All the outbursts had taken place in the neighbourhood of faults or igneous disturbances. It had been noticed that in approaching them the coal had been harder than usual. Mr. Robertson thought that this hard coal might be so dense as to prevent the passage of gas through it, and to act as a dam to the pent-up pressure of gas and disintegrated coal behind. So soon as the dam was sufficiently weakened, the pressure found an outlet. Boring in advance had been tried, but it had not prevented the outbursts.

Similar outbursts have been recorded as occurring at the Bességes mines in France, but fortunately in coal-mining generally they appear to be very rare.

Mr. W. Beattie Scott (H.M. Inspector of Mines) said that papers written by Mr. Joseph Dickinson * and Mr. Meachem † had dealt with the same question. Mr. Gerrard, however, had given no information as to the cause of these outbursts. Similar outbursts had occurred at

* *Transactions of the Manchester Geological Society*, 1893, vol. xxii., page 239.

† *Trans. Inst. M.E.*, vol. v., page 381; vol. xii., page 612; and *Transactions of the Manchester Geological Society*, 1896, vol. xxv., page 83.

Hamstead colliery and similar results had been observed, but the coal being hard and crystalline, large masses of coal had been thrown off by what were locally called "bumps." He presumed that the noises described by Mr. Gerrard were of the same nature. These noises would pass through many hundred feet of strata, and he had been wakened at night in his home by noises conveyed through 2,100 feet of strata. The noises were different from those heard about two years ago when earthquakes were felt in this country. What was the cause of such occurrences, and what precautions should be adopted to prevent them in future? After a long study of the matter, he put it down to nothing more than the pressure of the strata which forced out the material below; the softer coal was forced out; and if they could carry out experiments and put on as much pressure with a Brahma press as was exerted by 2,100 feet of strata they would force out the softer portions of the material with which they were experimenting.

Mr. T. Vaughan Hughes (Birmingham) asked whether any analysis had been made or any measurement taken of the volume of the occluded gases.

Mr. Arnold Lupton (Leeds) agreed with Mr. Scott that it was doubtless the pressure which had reached what he might call the "critical point" that had caused the bumps, and beyond the "critical point" the coal became completely disintegrated and fell into dust. But how did this theory explain the rush of dirt and inelastic material that ensued? And what about the warnings which were heard and were not accompanied by gas? He ventured to suggest for the consideration of the members that all coal contained gas, which did not come out in the cracks and fissures, but was contained in the coal itself, the pressure all at once passed the critical point, the coal fell into dust, and thus the gas that it contained was suddenly liberated, and this liberation of gas might be sufficient to throw the small coal forward, as described by Mr. Gerrard. The pressure required to lift a lump of coal, even of large dimensions, would not be very great.

Mr. Harry Rhodes (Rotherham) said that he had had some experience of outbursts of gas and water, accompanied by severe bumps, in a seam about 5 feet thick with a stone roof. He had heard the bumps, and large pieces of coal had been projected some distance away. There had not, however, been any damage done to the place, beyond the difficulty of getting into it, caused by the material thrown forward and the flow

of gas and water. The gas in several instances fouled air-currents, varying from 10,000 to 25,000 cubic feet per minute; and in some cases pressing back the intake air-current for considerable distances. Many safety-lamps had been extinguished, and in one case, two ponies were nearly suffocated. It was noteworthy that without exception, these outbursts of gas and water had all occurred in winning bords, and that the issues of gas and water speedily ceased; and that no outbursts had occurred in end places. The depth varied from 1,800 to 2,200 feet.

Mr. A. S. DOUGLAS (Hucknall Torkard) asked for information as to the depth of the hole bored after the outburst of July 21st, 1892, and the pressure of gas, if recorded. Some years ago, Sir Lindsay Wood read a paper before the North of England Institute of Mining and Mechanical Engineers * on the pressure of gas in the coal-seams at several collieries in the County of Durham. The pressures were considerable, and varied from 200 to 250 pounds to the square inch.

Mr. M. DEACON (Chesterfield) asked whether there was evidence of blowers of gas, independent of the bumps referred to. He thought that the duration of the outbursts was extremely short, apparently not more than 3 or 4 hours. He would also like to know whether there was anything in the appearance of the coal—that remained solid—which would indicate the existence of pockets in which the gas might be stored at a high pressure. In 1868, in South Wales, an extraordinary blower of gas occurred at the Abercairn collieries, and this blower was so gigantic that it had cleared out from 15 to 20 feet of a heading—that is, blew solid coal out of the heading, and formed an enormous coal-bank many feet in length.

Mr. J. A. LONGDEN thought that the paper was a very strong advocate for the longwall system of working, and he was of opinion that if the roads had not been driven into solid coal there would not have been nany outbursts of coal or gas.

Mr. W. BEATTIE SCOTT said that there was no gas at Hamstead colliery. The pressure-gauge did not register any, and therefore the question of gas at that colliery did not enter into the question under discussion.

Mr. JOHN GERRARD, replying to the discussion, said that the noises heard in connexion with, or prior to, the Broad Oak outbursts, were, he imagined, different to the noises accompanying the bumps of the Thick

* *Trans.*, 1880, vol. xxx., page 163.

coal-seam of South Staffordshire: the noises were always accompanied by issues of gas, the outbursts were coal and gas. He thought that definite evidence was afforded which would enable the members to form their own opinion as to the cause of these outbursts, in the record of facts together with the particulars of the mode of working which for 6 years had resulted in an entire absence of outbursts. It should be noted that the outbursts did not commence until 1,500 feet of cover had been attained, and as there was no appreciable difference in the conditions of the seam, it was evident that the outbursts were associated with the thickness of cover. If the pressure in pounds per square inch varied with the depth in feet, the pressure at the present time with a depth of 2,100 feet would be 2,100 pounds to the square inch. Analyses of the blown-out "minings" were recorded in his paper, but no analyses of the gas had been made. It would be difficult to determine the amount of gas given off, and independent of the outbursts there had been no blowers of gas. The depth of the bore-hole which on July 21st, 1892, gave a pressure of 14½ pounds to the square inch was 15 feet. It had been proved that there were areas of very soft, extremely friable coal, surrounded by a strong hard stratum largely containing fire-clay; and it was from these soft coaly areas that the gas issued to a certain extent, therefore these areas might be described as pockets or pounds of gas. The members would see from the samples exhibited the nature of the roof, clay, extremely friable coal and the coal of the seam. A microscopic examination of the coal forming the "minings" showed intense disintegration, a marked absence of vegetable tissue, and that it was an extremely carbonaceous mineral. Mr. H. F. Bulman described a case in which boring in advance had failed. Originally it was thought at Broad Oak that a small hole bored in advance of the face might be sufficient, but it had been proved insufficient. The lesson learned was, that boring must be systematic; and, now they place a bore-hole in the middle of each place, one in each side, and flank-holes 7 feet deep at intervals of 4 feet. In addition to systematic boring, he strongly held that other remedies had contributed to success, ceasing to leave pillars, and opening out into wide working, had also the effect of allowing the gas to escape gradually.

The PRESIDENT moved a hearty vote of thanks to Mr. Gerrard for his valuable paper, and the motion was cordially adopted.

The following paper by Mr. A. H. Stokes on "Castleton: History, Geology, Minerals and Mining," was taken as read:—

CASTLETON: HISTORY, GEOLOGY, MINERALS AND MINING.

BY A. H. STOKES, F.G.S., H.M. INSPECTOR OF MINES.

History.

The history of the Royal Manor of Castleton would be similar to the history of most of the small isolated villages of the Peak of Derbyshire, were it not for its historical castle, and as being the locality selected by Sir Walter Scott for his well-known novel *The Peveril of the Peak.*

It is probable that the original name was the Castle in the Peak, for old documents call it the castle of Pec or Peck, the castle of Peck or Peke, or Peveril's Place in the Peke, and latterly the name is Peak Castle, the village nestling immediately below the castle taking the name of Castle Town.

In driving from Sheffield to Castleton, we pass over high moorland country, the home of grouse and the wild flower, a district thinly sprinkled with homesteads, and where nature's aerial forces are seldom at rest. We ascend to a height of 1,340 feet above sea-level, and then, as we quickly descend to the village of Hathersage, we see below us one of the loveliest dales to be found in the county. The road and stream running parallel for some distance, the clear waters of the Derwent and the Noe, softly purling, glide along, by the roadway milk-white with triturated limestone; as both river and road wind their way at the foot of hills of steep inclination, surrounded by foliage of varying hues, they form a sinuous view of ever changing and beautiful scenery, and before we enter the Hope valley at its eastern extremity, there bursts upon us the broad expanse of a great pastoral area of fields and green meadows, with the two villages of Hope and Castleton ensconced in a magnificent amphitheatre of hills. The keep of the castle towers up as if proclaiming a defiance to the unwelcome marauding tribes, which formerly inhabited the district, should they attempt to enter the village.

We pass through the small village of Hope and in 1½ miles reach Castleton, situated on the south-western side of the valley, and seemingly surrounded by high hills, except in the direction in which the

visitor entered the valley : this is not so in reality, for there is a break in the hilly environment and a road passes out at the western end of the valley, leading to Chapel-en-le-Frith. Castleton was formerly difficult of access, the nearest railway-station being 7 miles away, but there is now a station at Hope, and we may be set down in a charmingly picturesque country within $1\frac{1}{2}$ miles of Castleton village.

The castle, or rather the ruin, occupies the summit of an isolated hill, the outer walls forming an irregular parallelogram, the interior being inaccessible except by an entrance on the eastern side overlooking the valley. At the western angle, there is a massive gritstone tower or keep, about 50 feet high, which consisted of two lofty rooms. The dimensions of the outer walls and the area of the enclosed space indicate that the place was never more than a fortress or garrison, as its small area would prohibit it from being the habitation of a court, such as was indispensable to the dignity of a feudal chieftain in those days.

There are indications that the present castle stands upon a site formerly occupied by a Saxon fortress. The architecture of what is left of the building would lead us to conclude that its erection dated from the Norman period, but like many such places, no record of its first stone laying is to be found, and we must refer to the *Domesday Book* for the information that the castle then belonged to William Peverel, a natural son of William the Conqueror: but it was lost to the Peverels in 1153.

The castle was taken by assault by the Earl of Derby in 1215, and Edward III. in 1373 granted the place to John of Gaunt, and from thence to the present time it has belonged to the Duchy of Lancaster. The present Constable of the castle is the Duke of Devonshire, by whose permission the ruins are thrown open to visitors. The village was once fortified, for the remains of a fosse and ramparts could at one time be traced round it.

The church at Castleton is dedicated to Saint Edmund, but this gives little information as to the date of the foundation of the village, for the Christian religion was probably not propagated as early in this part of Derbyshire as in some other parts of the kingdom.

There is no necessity to trespass further upon the domain of the antiquarian, but as engineers we can admire the foresight of our ancestors in selecting a place for a fortress, where nature had so strongly guarded the approach by the steep declivity of the rocks upon which it was built.

Geology.

The strata of Castleton may be described as Mountain Limestone and Yoredale rocks and shales.* The bold precipitous hillsides to the south, west and east, with their weather-beaten and almost bare-rock surface, show the stubborn resistance that the Mountain Limestone offers to the forces of change and decay by atmospheric agencies. In some parts, the blackened face of the exposed limestone stands out in bold relief, presenting an inaccessible front to the climber, and in majestic defiance of the united forces of time and climatic change to bring about its downfall and disintegration.

The Mountain or Carboniferous Limestone is so well known, and so unmistakable in appearance, that a student in geology would easily recognize it. It is the coal-miner's limit of descent in the strata forming the crust of the earth, and the field for research of the metalliferous miner of the county of Derby. It forms the bold escarpments which give shape to the picturesque scenery of the county.

There are a few quarries near Castleton working the limestone. It is used for burning into lime, building purposes, and, broken up for road-metal, the white appearance of the roads round Castleton being due to the limestone used for repairing them. A large quantity of limestone is used for building dry stone walls round the fields, for the bleak situation is unsuitable for the growth of hedges.

The boundary of the Mountain Limestone can be easily traced at many points, for its limit is frequently defined by an abrupt termination in the contour-line of the county, its cold, bleak and nearly bare rock-surface giving unmistakable indication of its character.

It is to the north-west of Castleton that the northernmost point of the exposed limestone is seen, and within a few feet of the bottom of Mam Tor. Beyond this point the limestone dips below the Yoredale rocks and shales, and is not again seen to the north in the county.

The limestone is not one solid mass of rock, of an uniform character and unknown thickness, but is intersected by beds of chert and cherty limestone, and occasionally a contemporaneous or intrusive sheet of igneous rock or toadstone; we also occasionally find a parting of clay and shale, and a contortion of strata with huge faults that arrest the eye, and cause the mind to speculate as to the enormous force and erratic upheavals which must have taken place throughout the district.

* The author is aware that a geologist would probably use the term Yoredale rocks, but a mining engineer would not call a micaceous grit-rock a shale, neither would he term shale a rock, and near Castleton the alternate layers of shale and hard rock are so clearly defined that the term Yoredale rocks and shales appears the best definition for a mining engineer.

Many of the usual characteristic fossils of the Mountain Limestone are to be easily found in the stone quarry in Cave Dale, on the south-eastern side of the castle, and within a few feet of the church. In or about this quarry will be found *Productus* and *Terebratula* with little difficulty of search.

Those who have studied the palæontology of the Mountain Limestone will have no difficulty in assigning its origin to marine conditions, and those who desire to question whether the limestone was a deep or shallow-sea deposit at Castleton should examine the small quarry about half-way between Castleton and the Speedwell mine, on the left-hand side of the road leading from Castleton to the Winnats, where Messrs. J. Barnes & W. Holroyd * state that the remains of a sea-beach appear in the limestone-formation, and from this, it is supposed, that whether the lower limestone be a deep-sea deposit or not, the upper beds round Castleton must have been deposited in shallow water.

On the northern side of the Hope valley we have hills of Yoredale rocks and shales in places capped by Millstone Grit, but with the exception of Mam Tor, there is an absence of bold precipitous sides, for the shales have crumbled away, until the ascent from the valley for some distance up the hillsides is a gradual and easy inclination, the green pasture-fields extending much higher up than on the Mountain Limestone side.

The hill called Mam Tor, or the shivering mountain, is one of the sights of Castleton, and is seen on a clear day all up the valley and for miles around. It is a hill composed entirely of Yoredale rocks and shales, the side facing Castleton has been so acted upon by the weather that it presents a bold and almost vertical face of exposed rock and shale for a height of upwards of 400 feet above the roadway at the bottom. It exhibits a fine section of shales and beds of micaceous grit, each from a few inches to over a foot in thickness. The shale-beds are constantly weathering away and falling to the bottom, where a large mass of detritus has accumulated and is slowly pushing its way into the valley below. This constant wasting away of the shales has suggested the name of the "Shivering Mountain." The beds of hard rock are a support to the shales, and it is the support from these beds that protects the mountain-side from rapidly wasting away and causes it to retain its almost vertical face. The top of Mam Tor is 1,100 feet above Castleton, and 1,700 feet above the level of the sea. An examination of the face of the mountain and a journey to the top will

* *Transactions of the Manchester Geological Society*, 1896, vol. xxiv., page 215.

repay the geologist and those who wish an extended view over the beautiful valley of Edale on the opposite side of the mountain.

The roadway at the bottom of Mam Tor, winding round to Castleton, may be taken as the boundary-line between the Yoredale rocks and shales and the Mountain Limestone.

The most interesting geological feature is the "toadstone." This is the local name for an igneous rock found between the beds of limestone; it is sometimes called "channel," and occurs in various forms. It may be hard like basalt, or concretionary and vesicular, or it may be found decomposed into a soft greenish clay, when the miners call it "cat-dirt;" in some cases. if the clay be washed, nodules of calcite can be obtained from it. A bed of toadstone is found coming out on the hill side of Cave Dale, to the south-west of the castle, and many pieces may be seen in the stone wall, built to form a fence to the foot-road which passes at the back of the castle.

A nice geological problem is raised as to whether this was an intrusive mass of igneous rock, or whether it was contemporaneous with the limestone. There may be exceptional cases, but it is generally admitted that the volcanic eruption, in most parts, was contemporaneous with the deposition of the limestone; in some cases the limestone lying below the toadstone bears traces of the action of heat, whereas the beds of limestone overlying the toadstone show no such traces. We have also the amygdaloidal character of some of the toadstone, which may be due to water, impregnated with calcium, having covered the mineral whilst in its hot state, the small steam-cavities then formed being now found filled with calc-spar. We have also the hard, solid variety, which does not appear to have been acted upon by water, and was probably cold before the limestone above was deposited. So also the finding of bedded volcanic ash deposited under similar conditions supports the contemporaneous theory. On the other hand, we find the toadstone cutting out the lead-veins, and presenting the appearance of having been an intrusive flow after the formation of the veins. The unevenness of the bed of toadstone, both at the top and bottom, conveys the impression that it was a viscous mass, pushing its way to fill up horizontal cavities in the limestone made by natural upheavals or water-worn openings; or perhaps such openings were due to both actions. But again, we find veins occasionally passing through the toadstone, and even the bed of toadstone distorted at a vein, one side of the bed being considerably higher than the other side where the vein passes through, showing that the interbedded toadstone had been deposited before the

disruption of the limestone occurred. The bed of toadstone being once formed across a vein, there would be little chance of communication between the vein below and that above, unless a break occurred, for the toadstone is an impermeable barrier to water; but when broken and faulted there would be a continuation of the vein through the toadstone, and equal facility for the formation of the mineral either above or below the bed of toadstone. The formation of beds of toadstone between the beds of limestone, how, when, where and by what means they came there, and their history, is a knotty geological problem; and while the balance of evidence is decidedly in favour of a contemporaneous deposit with the limestone, yet there may be some exceptional cases which support the intrusive theory. Probably the greater part was contemporaneous; and there may be intrusions also. Whether it came from one huge volcanic neck or opening having subsidiary necks over a wide radius round the same, or whether it came up from a number of rents at various parts of the county, is a problem yet to be solved. The probability of a number of rents is strongly supported by some shafts having been sunk into the toadstone and not bottomed, whereas shafts near them have passed through the bed into the limestone below, and also by the finding of toadstone with ash and pieces of limestone, indicating a pipe or rent from which the toadstone came up. The number of beds of toadstone, and the extent of their flow over the county, is not yet settled. There may be three beds, or more, and their thickness varies, as might be expected with a lava-flow, probably upon an inclined bed.

The Castleton and Hope valley is upon Yoredale rocks and shales, or more probably the upper stratum consists of *débris* from the wasting away of the hills surrounding the valley to the north; the Mountain Limestone dips away under the Yoredale to an unknown depth.

There is a small strip of alluvium or river-gravel, which follows the line of the rivers Noe and Derwent, and although a cursory view of the Hope valley may lead us to think that the lower part is an alluvial flat, yet it is more likely a detritus-fan from the Yoredale rocks and shales, which form the hills to the north of the valley.

Minerals.

Lead-Ore.—The lead-ore found is galena, and usually occurs in rake-veins or fissures in the limestone: the fissures having been filled up with layers of calc-spar, barytes or fluor-spar, and lead-ore, such veins by their appearance convey the impression that they have been

deposited layer after layer upon the walls of the fissure. The size of the veins of ore and mineral varies from a mere thread to a mass of considerable width. The smaller veins are called "scrins," and are the least productive of the veins. In some cases, huge caverns are found, having the walls coated with dogtooth spar and bunches of crystallized ore.

The veins of ore are not confined to the Mountain Limestone, but they are occasionally found in the Yoredale shales or, traced by a thread-like vein, passing through toadstone, and some miles west of Castleton a good vein of lead-ore was found passing through a coal-seam.

The most productive veins yet discovered are those found in the limestone immediately below the Yoredale rocks and shales, the lower beds of limestone not being good ore-beds. How the mineral was deposited, or grew on the walls of the limestone-fissure, whether by an aqueous sedimentary deposit, or an upward sublimatory operation, is a question left for the study of the mineralogist.

Zinc-ore (Sulphide of Zinc, Blende, Black-jack or Mock Ore).—Zinc-ore has been found at the Pindale mine, a little to the east of Castleton. It occurs in connexion with lead-ore, and is not worked as a separate mineral. In appearance it is very similar to lead-ore, especially as it leaves the crusher or mill, but from its specific gravity, being about half that of galena, it is easily separated when the ore is washed. It is generally understood that good veins of lead-ore and zinc-ore seldom occur together.

Barytes (Sulphate of Baryta or "Cauk").—This mineral is found in all the mines about Castleton, and in many cases forms the coating of the vein to which the lead-ore adheres. In olden times, this mineral was considered worthless, but since its commercial value has become known many of the spoil-heaps have been worked over for barytes alone.

Iron-ore (Bog Iron-ore).—This ore exists in a field to the east of the Odin mine, but is of no commercial value, only cabinet-specimens being obtained.

Calc-spar (Calcite).—This mineral, like barytes, is obtained in connexion with lead-ore, and is found adhering to the walls of the veins. It is seldom worked as a separate mineral, and the quantity now found and used for ornamental purposes is obtained from the hillocks or heaps at old lead-mines.

Fluor-spar.—The "Blue John" variety of fluor-spar is singular to the Castleton district. It has long been known for its beautiful

concentric layers of coloured spar, and is worked only at the Blue John mine, about 1 mile north-west of Castleton, where the quantity raised is limited to a maximum of 3 tons a year. The whole of the output of the mine is used for ornamental purposes, principally trinkets and small vases. It is of varying colour, from a light yellow to a very dark purple, and occasionally specimens are ruby red, the colour in some cases being altered from its natural state by firing, which changes the violet purple of the mineral into a red or reddish purple. It is found associated with barytes and arranged in concentric layers of a few inches thick, adhering to the sides of the caverns and walls of the veins in the Mountain Limestone-formation.

Bitumen.—Both the elastic and the hard or brittle variety of bitumen are found in a limestone-quarry a little to the west of the Blue John mine. The elastic variety is a soft, sticky mass, found between broken pieces of limestone, and near the surface of the field. The hard or brittle variety is found in short sticks, similar in size and shape to a lead-pencil, but not quite so thick. It is of no commercial value, but its rarity causes it to be sought after for cabinet-specimens.

Jasper.—Small thin veins of jasper can be found in the basaltic rocks at the top of Cave Dale, at the back of the castle. It is only sought after as a cabinet curiosity.

Mining.

The singular and unique mining customs of the High Peak of Derbyshire have from time immemorial given to all subjects of the realm a right to search for, sink and dig mines, for working lead-ore within the King's Field, upon payment of certain dues to the Crown. In ancient times, lead was necessary for the defence of the country, therefore the Crown reserved the right of working lead under the Crown lands of the Peak, and encouraged miners to get the ore by rights and privileges of an unusual character. The ancient laws, customs and duties were embodied in an Act of Parliament in 1851, and secured to the miners of the Peak their old privileges. Such ancient laws were, no doubt, an enlargement of the Roman laws, which would be in force when the Romans mined for lead-ore.

It is lawful for all the subjects of the realm to search for, sink and dig mines or veins of lead-ore upon, in or under all manner of lands whose inheritance soever they may be, except churchyards, orchards and gardens. The miner can enter upon any person's land without asking permission, he can commence to sink or cut out the vein, and upon payment

of a dish of ore (about 15 pints) to the Barmaster, he frees the mine and is entitled to the exclusive use of so much surface-land as shall be thought necessary for laying the rubbish, dressing the ore and for other mining purposes. He shall also have a cart-road from the nearest highway to the mine, and access to the nearest stream or spring of water, and for all this he makes no payment or compensation to the occupier or owner of the soil: probably no cheaper mode of obtaining a mine can be found in the kingdom. The landowner, however, does receive compensation, for he can take away from the mine and sell, all minerals other than lead-ore, without any payment to the miner.

A full account of the mining customs, with other information respecting the mines and mode of working, will be found in a paper read before the Chesterfield and Derbyshire Institute of Mining Engineers,* and a supplementary paper.†

There are no lead-mines now at work at Castleton; all are standing, their white hillocks or spoil-heaps testifying to bye-gone days of prosperity.

The entrance to a mine is usually by a number of shafts and levels. The shafts are not always vertical, but may follow the hade of the vein, and there is generally a shaft from one level to the other. The ore is drawn up a shaft to the surface by horse-gins or a jack-roll worked by hand, such shaft being vertical and common to all the levels. The mode of proceeding to work is by means of the climbing shafts, which may have either ladders fixed in the shaft, generally vertical, or a number of stays or stemples fixed across the shaft, and between which the miners straddle from one stemple to the other, holding by the hands to the stemples from which their feet have been removed; and thus having descended one shaft for a few feet, the miner travels along a level a short distance, and then down a similar shaft to another level, and so on to the bottom level.

As the vein is cut out, the roof of the level or roadway is formed by the insertion of strong bars from one side of the limestone-wall to the other, forming a strut across the vein. Such bars, called "bunnings," are "slabbed" over, and then the "deads" or waste are thrown on the top. In a large mine, the stoops are carried forward at different heights, the upper one in advance, and so on to the lowest stoop or level.

The finding of pigs of lead with Roman inscriptions, and the name of some of the mines, points to the antiquity of lead-mining in Derby-

* *Trans.*, vol. viii., page 67. † *Ibid.*, vol. ix., page 306.

shire, and probably the lead-mines in Derbyshire were the first worked in Britain. One of the pigs of lead found bears an inscription dating between 117 and 138 A.D., and a further proof of the antiquity of mining in the district can be recognized by the "firing" indications which are found in the old workings. It was the only way that the miners had of getting the ore before the introduction of gunpowder, which probably did not reach Derbyshire until after 1636.

Odin Mine.—The Odin mine lies 1 mile north-west of Castleton, and is mentioned in *Domesday Book* as one of the mines in Derbyshire. It was at work in 1783, and was considered a rich mine, employing about 100 workpeople. It yielded both lead and barytes. At whatever time the mine was commenced, it is certain, from the present appearance of the abandoned workings, that it was at one time of great importance. The vein has been cut out to the surface, but a shaft was sunk on the east of the roadway. This shaft is stated to be about 300 feet deep, and a water-level or adit was driven from Castleton to unwater the mine.

Pindale Mine.—This mine, situated about 1 mile east of Castleton, has been recently worked, but is now standing. Both lead-ore and zinc-ore (calamine or black-jack ore) were got from the mine, and it is interesting as being a mine in which ore was found in the toadstone.

Caves or Caverns.—There is no lack of magnificence or variety in the caverns of the Castleton district, and within a radius of about 1 mile from the centre of the village the visitor can see both natural and worked caverns of large extent. How these caverns came to be formed is a question which may be answered by a study of the geology of the district. Owing to natural dislocations and distortions of the limestone, there are numerous breaks and fissures from the surface downwards, some now filled up and forming lead-veins, others open, down which the natural drainage of the surface-land descends and is lost to view: such holes at the surface are termed "swallows," and a number of these are to be found west and south of Castleton. In some cases, a considerable stream of water disappears suddenly down one of these swallows, and after passing by tortuous subterranean passages it issues from a hole or fissure in the limestone, at a lower level, some miles away. Such water may be more or less charged with carbonic or other acid, which would have a erosive action upon limestone, and if the water was made to pass along one of the natural breaks in the limestone, it might in time eat away the limestone rock and enlarge its area of passage until the cleft was able to take a considerable stream. In some

cases, the limestone-walls seem to offer a stubborn resistance to the action of water, whereas at other points the water appears to have met with limestone more readily attacked by the acid solution and easily giving way to its solvent action. At such a point an enlarged space occurs, where, after ages of corrosion, a cavern is formed, whose waters are more or less constantly agitated by the inrush of water which washes away the walls until man, in search of minerals, lets loose or diverts the impounded water, and a cavern is discovered, to become the show-place of the district.

Peak Cavern and the Blue John mine are the principal caverns. They have been so often and so minutely described in guide-books that little new can be said of them, and a visit will convey more than words can express. The water now flowing through the Speedwell level into the Peak Cavern and out below the castle is supposed to come from the swallows at Sparrow pit, 2 miles south-west of Castleton, for when the mines were working at Sparrow pit, the water flowing from the mouth of Peak Cavern bore indications of mining operations. Hence we have caverns natural and caverns artificial, the natural ones formed by the action of water passing through a broken up limestone, and the artificial portions made by the miners in their search for lead-ore.

Speedwell Level.—This level is entered by an opening at the foot of the Winnats. The level was driven to unwater the mines to the south-west, and according to old records was driven at the rate of 6 feet per week at a cost of 16s. 8d. per foot. It took some years to complete, and after reaching a distance of 2,250 feet from the entrance it cut into an enormous cavern, which is now the centre of attraction to visitors. The size of this cavern has not been ascertained, but some idea of its depth may be formed, for it is reported that the level was driven 1,800 feet beyond the cavern, and the rubbish thrown into the chasm without producing any visible effect.

The first part of the level and cavern is now used as a show-place. Visitors at the entrance get into a boat, and are poled along the water of the level until they arrive at the opening to the cavern, where they alight, and, standing upon a stage, look upon the water of the level rushing with an awful roar into the dark abyss below.

The driving of the level by pick and wedge, and so very straight, in hard limestone is well worth noting by mine managers, who find considerable difficulty in getting a few feet of heading, in a comparatively soft mineral like coal, driven without losing the sight-lines, or a liberal amount of "cheeking" to keep them anything like straight.

Lead Veins.—The veins of lead-ore are of various widths and inclination. They appear to be cracks or breaks in the limestone, which have been filled up by mineral deposit, commencing on each side until meeting in the middle the whole becomes a solid mass of calc-spar, barytes and lead-ore. The lead may form a continuous thin layer; or it may appear in isolated patches indiscriminately scattered through the mass of spar or barytes; or where the vein is large and open the lead may be found adhering to the sides in crystals and bunches of ore, as in cavernous openings; or it may be found in patches mixed up with calc-spar, barytes and pieces of limestone, the whole having the appearance of a broken up mass of mineral fallen down, and afterwards cemented together by a calcareous deposit.

Wherever the veins are found and of whatever description, either rake-veins, pipe-veins or flats, they appear to be the filling up of joints, cracks, or dislocations in the limestone, which may or may not have been enlarged by a flow of water before the mineral deposit commenced to form on the walls. Rake-veins are usually nearly vertical and similar to a fault in the Coal-measures. Pipe-veins or pipe-like enlargements are met with in rake-veins, and flat-veins or veins of alternating width between the beds of limestone are the filling up of waterworn cavities.

When the veins are marked upon a plan there is a certain similarity of direction observed, but this is little guide to their continuation or productiveness, neither is the nature of the limestone of much use as a guide to productive veins, and the only sure method is that of actual exploration by mining.

The mode of working the lead-mines, and the washing and dressing the ore are fully described in a paper, "Lead and Lead-mining," published in the Transactions of the Chesterfield and Derbyshire Institute of Mining Engineers, and those who wish to study the question are referred to that paper for a full description of lead-mining in Derbyshire.*

Conclusion.

The mining history of Castleton is a record of past glories, of work commenced under crude conditions and involving much physical labour to obtain what was then absolutely necessary for the defence of the country, as well as for the domestic comfort of its inhabitants and the protection of its buildings. The struggles of the miners to retain their immemorial rights, and the hard labour of the mining operations, are a

* *Trans.*, vol. viii., page 67; and vol. ix., page 306.

record of unwearied tenacity well worthy of a race of men who have been branded as "strong in the arm, but weak in the head," whose dogged determination to wrest the ore from nature's grasp, and at the same time exercise their rights to "dig and delve" in any part of the King's Field, proves that their arm was without doubt strong and their will not less so. Their success in holding to the present day their rights, now confirmed by Act of Parliament, is a proof that their brain-power was strong enough to retain what had been handed down to them by their forefathers, and eventually to persuade the intelligence of the legislature to grant them an Act, an operation which men of greater mental culture have occasionally failed in carrying through successfully.

Lead-ore may still exist at greater depths, but until it commands a higher price in the market, and modern machinery is erected, it is probable that Castleton will remain a place of holiday-resort for the pleasure-seeker, of study for the archæologist, and a monument to the miner's first operations in the Peak district of Derbyshire.

The CHAIRMAN moved a vote of thanks to Mr. Stokes for his paper, and the resolution was cordially approved.

Mr. J. A. Jones' paper on "The Devonian Iron-ores of Asturias, Spain," was taken as read, as follows :—

THE DEVONIAN IRON-ORES OF ASTURIAS, SPAIN.

By J. A. JONES.

Geographical Position.

The principality of Asturias is situated in the north of Spain, having the Bay of Biscay for its northern boundary; on the east it adjoins the province of Santander; on the west it has the province of Lugo, and on the south the province of Leon. Its boundary-line on the east and south is carried along the top of the Cantabrian range of mountains, which forms a barrier, separating it from the rest of Spain. Communication is carried on by roads through the various passes between the peaks, and by the present single line of railway. The highest peak has an altitude of 8,464 feet.

The topographical features comprise hills and valleys, with but little level ground throughout. The greater portion is well wooded, the eastern and southern heights being covered with beech and oak; the western portion with pine forests; the valleys with apple, pear and hazel; and the lower reaches of the hills and mountains with groves of chestnut.

The climate is temperate near the coast, but subject to increased variation up the mountain-sides, ranging in the former from 46° in winter to 80° Fahr. in summer, and in the latter from 21° to 97° Fahr.

There are five general river-courses with deep-cut beds, which drain the whole system effectually. Three of these have important estuaries, but they are heavily silted by the sand carried down. Nothing has been done to keep clear channels in them; they are, therefore, ill adapted for sea-ports.

The coast-line is indented, and the jutting capes shelter the coves from the Atlantic swell, which is heavy during westerly winds. The prevailing winds on the coast are north-easterly during spring, summer and autumn, and westerly to northerly during the winter months. The latter are the only winds that produce rough seas.

The shipping ports along the coast are, taking them from east to west:—Tina Mayor, where the calamine from the Picos de Europa is shipped. Llanes, a small port with a little traffic in the shipment of bricks and tiles, Rivadesella, on the estuary of the river Sella. Gijon, the port

of greatest importance, a tidal harbour, where the shipment of coal from the extensive coal-fields of Asturias is effected; here also the product of the various steel and iron-works is shipped, and pit-props for the mines and iron-ore for the works are imported; and in addition there is a large importation of grain, and timber from the Baltic. A direct line of Liverpool steamers calls at Gijon every 10 days, and another line of Antwerp boats fortnightly. Avilés is a good port where coal is also shipped, and pitch for briquette-fuel, timber, grain, etc., are imported. Luarca, a small sea-port, with shipments of pine-props for colliery uses. Navia, a small port in the estuary of the river of the same name, like the former, a loading port for pine-props. And Tapia, a shipping port for pine-props and iron-ore from the mines in the Porcia district, which will be referred to below.

Geological Features (Plate IX).

Asturias has been the field of numerous seismic movements, and there are many geological formations in view to-day. Without taking into account the various patches of diorite and other eruptive rocks, the formations may be recorded as shown in Table I.

Table I.—Geological Formations of Asturias.

Formation.	Area.	Minerals Contained.
	Sq. Miles.	
Silurian (*a*)	1,450	Auriferous quartz, molybdenum, and antimony.
Devonian	750	Iron-ores, copper and mundic.
Rich Carboniferous (*b*)	650	Coal and fire-clay.
Poor Carboniferous and Permian	800	Copper carbonates (*c*), manganese (*d*), calamine, and blende.
Trias	150	One salt-spring known (but not worked), and gypsum.
Jurassic and Oolite	150	Jet (*e*), and thin beds of lignite.
Cretaceous (*f*) ...	160	Gypsum and some irregular beds of limonite, contaminated with iron-pyrites, and of no value.
Eocene (*g*)	12	Sterile.
Recent (*h*)	80	The western portion of the province holds alluvial gold.

(*a*) A part of this formation is the older Cambrian Series, as is proved by the presence of chiastolite crystals, met with in the rocks of a portion of the river Navia accompanying semi-crystalline schists, at about 16 miles from its mouth.

(*b*) This formation comprises every description of coal from anthracite to gas coal.

(*c*) The copper carbonates are poor, and assay from ½ to 4 per cent. of copper.

(*d*) The manganese is met with in lodes and pockets. Overlying a portion of this formation at Covadonga, there is a vast bed of boulder-clay, due to glacier-action, with a thick bed of manganese at the base at present being worked, assaying as follows:—Manganese sesquioxide, Mn_2O_3, 62·40; manganous oxide, MnO, 31·11; ferric oxide, Fe_2O_3, 2·02; alumina, Al_2O_3, 0·45; lime or calcic oxide, CaO, 0·66; magnesia, MgO, 0·27; sulphur, S, 0·04; phosphorus, P, 0·05; silica, SiO_2, 0·70; water, H_2O, 2·10.

(*e*) The jet has been extensively worked, and shipped to Great Britain to supply the manufacturers at Whitby with the raw material, their product being put on the market as produced from "real Whitby jet," thus proving that the quality is identical.

(*f*) The Cretaceous formation is well represented by its Lower Greensand, with *Ancyloceras*, *Perna Mulleti*, and *Nautilus plicatus*. In another portion of the formation, the layer of flints proves the existence of Lower Chalk, although in the series no chalk (white earthy carbonate of lime) is found.

(*g*) This formation is represented by a bed of Nummulitic Limestone, composed of an almost compact mass of nummulites.

(*h*) This formation is limited, and consists of the detritus of the respective formations whereon it rests. The bed and banks of the river Navia and its tributaries hold gold.

The superficial area of the principality approximately is 4,202 square miles.

As the object of the present paper is to to examine only one of the series, in so far as it concerns its iron-ore deposits, it would be out of place to detail the geological subdivisions of the various series, and a cursory outline is considered to be sufficient. It may, however, be stated that here is a field for the geologist, since such work as has been done by those who have gone before is very limited and full of errors, which meet one at every step.

It may be premised that the province is made up of vast synclinals and anticlinals, with here and there heavy foldings, the average dip on either side of these being about 30 degrees from the horizon.

The Devonian Iron-ores.

These iron-ores have been made the object of careful study, as they form from 50 to 65 per cent. of the consumption of the blast-furnaces of the province. The deposits are in part owned and worked by the companies noted in Table II., which also records their make during 1898.

Table II.—List of Iron-works.

Name.	Production.			Remarks
	Pig-iron.	Siemens-Martin Steel.	Finished Iron.	
	Tons.	Tons.	Tons.	
Mieres Iron-works	17,478	5,480	14,562	The steel consists of plates and angles, and the finished iron comprizes plates, bars, angle-iron and hoop-iron.
Felguera Iron and Steel-works	18,130	11,193	14,379	The steel consists of plates for ship-building and other purposes, angles and bars, and the finished iron of plates, angles, merchant iron and hoop-iron.
Moreda and Gijon	20,000	—	9,100	The finished iron is a small portion of merchant iron and angles of small section, the greater portion being wire of various dimensions, for the most part drawn, and worked up into wire nails, 54 machines being used for this purpose.

The ores vary in iron content from 38 to 50 per cent., as some portions of the beds are richer than the others. An assay of the best is as follows :—

	Per Cent.
Peroxide of iron	64·24*
Protoxide of iron	7·42*
Peroxide of manganese	0·95
Alumina	3·65
Lime	1·60
Phosphoric acid	1·28†
Combined water and carbonic acid	3·10
Insoluble residue	16·20

* Containing 50·98 per cent. of metallic iron. † Equivalent to 0·56 per cent. of phosphorus.

The poorest ore has its deficiency in percentage of iron made up by an increase in that of silica, without altering to any important degree the remaining constituents of the ore.

Mode of Occurrence of the Iron-ore.—With the exception of one district (that of Bayo, which will be noted later), the iron-ore is found in regular beds in concordance with the encasing strata. These beds may be considered as original sand-beaches impregnated by and cemented with iron peroxide. The abundant fauna contained in them throughout, comprised of *Annelidæ* and *Spiriferidæ*, indicates their formation in shallow salt-water lakes. The iron impregnation would result from the abundance of iron in the state of peroxide in the soil and existing rocks of the period. The iron in the presence of decaying organic matter would be dissolved out in the state of soluble protoxide, which, charging the drainage-water, would find its way to the lake. In its movement it would absorb oxygen, and the metal as a consequence would be precipitated as hydrated peroxide, and this action would be continuous so long as iron was left in the rocks and soil. When the iron had been removed, the demolishing action of air and water would continue upon these rocks and soils denuded of their iron, carrying the finely divided material to the lake to form the clay-slates that to-day encase the beds. That the iron had been removed from them is proved by assay, or even by simply calcining them, when they yield a grey residue without iron coloration.

To permit this continuous action over vast intervals of time it must be supposed that this lake would be situated at such an elevation above the ocean of the period as to be beyond the reach of the enormous oceanic tides, due to the proximity of the moon to the earth.

The workable beds of iron-ore are set forth in Table III.

The lower bed rests also on slate, and the upper one has a covering of the same rock—the former bluish, the latter yellow. In concordance with these beds comes the Old Red Sandstone of great thickness and perfectly regular in its lie.

Such are the general characteristics throughout the series, which

TABLE III.—IRON-ORE BEDS.

No.	Strata.	Thickness.
		Ft. Ins. Ft. Ins.
1	Lower Iron-ore	4 11 to 9 9
	Clay-slate...	19 0 to 100 0
2	Middle Iron-ore	3 7 to 6 6
	Clay-slate...	28 0 to 196 0
3	Upper Iron-ore	3 0

extends from the coast of the Bay of Biscay southward through the province and into that of Leon, a total distance of 91 miles, with a width over the surface of nearly 18 miles. If the several anticlinals and synclinals be considered, it may be estimated that the width of this Devonian lake was approximately 100 miles, and its area would be about 9,100 square miles.

Leaving out of calculation the portions of these beds that are not within easy reach of existing ports—of the coast where loading-stages may be erected, or railways within a reasonable distance of sea-ports—it is well to consider those portions that meet export-requirements. For the purpose of examination, the deposits may be grouped as follows:—

No.	District.	Nearest Port.	Remarks.
1.	Canciense and Molleda ...	Avilés	...
2.	Candas	— ...	Shipping facilities have to be created for these deposits, as none exist at present.
3.	Naveces	— ...	
4.	Llumeres	— ...	
5.	Carreño	Gijon	...

1. *Cancienes and Molleda.*—Here there is a railway-station. The transport of iron-ore by rail to the ship's side in the port of Aviles costs 1 peseta 8 centimos per 1,000 kilogrammes. From Gijon, it is distant 29 kilometres (18 miles), and transport costs 2 pesetas 75 centimos per ton.*

Within a distance of 2 kilometres (1¼ miles) from the station there are some mines, working the outcrops of the veins near the top of the hills along which they run (these hills form the anticlinal line, with denuded apex, so that the ore-veins run on the opposite sides). The ore averages 45 per cent. of iron, and is delivered to the Moreda and Mieres works. It is conveyed to the station by bullock-carts, which take about 18 cwts. at a time. At the station there is no facility for loading, so that the carts have to be dumped on a level with the rail, and the ore shovelled into trucks. It is sold, put on truck, at 5 pesetas per ton. With a capital

* Exchange varies greatly: from 30 to 55 pesetas are equal to £1, and a peseta contains 100 centimos.

outlay of £1,500, to open up the mines, construction of a tramway to station, and a loading-berth, to permit the tipping direct into trucks, the ore produced could be put on board steamer in the port of Avilés at a cost (including amortization) of 4 pesetas 50 centimos per ton. The veins extend over a length of 3 kilometres (1·8 miles), and there are three parallel veins of 1 metre (40 inches) each, and 260 feet of backs can be opened by adit-levels, to yield after allowing for wastage 2,116,800 tons of ore.

At Molleda, on the opposite side of the hills to the Cancienes mines the veins are thicker. One mine has been extensively worked on the outcrop. The vein worked has a thickness of 6 feet 6 inches, with a dip of 40 degrees from the vertical, yielding ore averaging 48 per cent. of iron. It can be opened by adit to have backs of 360 feet, exposing in that vein alone 308,000 tons. In addition, two other veins of 1 metre (40 inches) and 1·10 metres (43 inches), to-day intact, would be opened, more than duplicating the tonnage to be worked. This ore would cost, free on board in Avilés, 4 pesetas 50 centimos per ton.

2. *Candas.*—This, as it exists to-day, is a small fishing port on an indentation of the coast, sheltered by a cape, with deep water at its foot on the sheltered side. Its chart is shown in Fig. 2 (Plate X.).

Here the seams have their greatest development throughout the series, as there has been extensive denudation of the saddle of the anticlinal, and numerous outcrops are developed on the lateral sides. The whole district has been pegged out, but only one mine is now working. The tops of the seams in many places have been exposed by exploratory workings carried on many years ago. Assays of samples taken from the beds gave the results recorded in Table IV.

TABLE IV.—IRON-ORES OF CANDAS.

Name of Mine.	Thickness of Seams Exposed.			Iron Contents.	Distant from Candas.
	Metres.	Ft.	Ins.	Per Cent.	Feet.
Marina 2ª	1·10	3	7	37·85	Adjoining.
Marina 3ª	1·10	3	7	36·30	7,250
Lo Preciso	2·00	6	7	45·31	4,000
,, ...	0·80	2	8	49·95	,,
,, ...	0·80	2	8	36·30	,,
Marina 4ª	1·00	3	4	54·84	8,250
Riestra	1·00	3	4	52·80	8,000
Regueral	1·22	4	0	47·43	11,000

At Marina 2ª, the percentage is too low for the ore to be worked for the present. The cost of the ore put on board, if once facilities were created in Candas, would be 2 pesetas 80 centimos per ton.

At Lo Preciso, there are several old workings on the outcrops of the veins, and with a suitable capital outlay for deadwork and tramway, 468,000 tons of ore could be worked, costing 3 pesetas 60 centimos per ton on ship-board in Candas.

At Marina 4ª, a large quantity of ore was worked from one of the veins some 20 years ago. Since then nothing has been done. The veins dip at 10 degrees from the vertical, with strong slate walls. A tramway to Candas would have a length of about 8,000 feet. If a tramway be laid from the Regueral mine to Candas, it would pass through this mine and serve it also. The mine must be reopened by adit to get into virgin ground, as the old stopes are choked by the fallen side-walls. Above adit-level, there are 537,600 tons of ore to be worked.

The observations respecting Marina 4ª apply also to the Riestra mine, which is located on the same run of veins.

The Regueral mine is at work, the ore being sold to the Moreda works. It is carted from the mine to the Veriña railway station (distance, 10 kilometres, or 6·2 miles), there loaded on to trucks and railed to the works (distance, 5 kilometres, or 3·1 miles). The working is carried in the vein to right and left, with a stope of 6 metres (20 feet). The encasing rock is a strong bluish slate that stands well, requiring but little timber. There are pine-forests in the vicinity, and timber is cheap. A vertical section of the workings is shown in Fig 3 (Plate X.). The tramming of the ore from the workings to where it is dumped for the carts is done by various movements, owing to the following causes :—The lower adit was started alongside a small stream, and parallel with this in Keuper Marls, with a view to cut the ore with good backs. But percolation loosened the strata, and it was found that the miners could not continue this level. A rise was then put up to the surface, protected with close timbering. The upper open cut was then started until they struck the ore, and the attle-heap formed a ramp between that level and the pit. The ore is dumped over this ramp into the pit, then filled again, and trammed to the cart-dump. All this useless labour could be avoided by driving an adit 512 feet long away from the effect of the stream, by which they would secure backs of over 200 feet, with a length of 5,250 feet, producing from No. 1 seam above the adit about 384,300 tons. The two remaining seams would have more backs, and therefore it may be safely estimated that the mine could produce over 1,000,000 tons. A tramway, about 3 kilometres (1·86 miles) long, to Candas would permit of the ore being placed on ship-board at a cost of 3 pesetas 80 centimos per ton, amortization and interest included.

The Dormon mine is situated about half-way between Gijon and Candas, *i.e.*, west from Gijon about 5 miles. The veins crop out in the face of the coast-cliffs from top to bottom (a vertical height of 260 feet). They dip at 30 degrees from the vertical. The upper seam has a thickness of 3 metres (9·84 feet), and samples taken from this assayed 47·60 per cent. of iron. The middle vein is 1·10 metres (3·61 feet) thick, and the lower one 1 metre (3·28 feet). To work this deposit it will be necessary to construct a loading-stage as shown in Fig. 4 (Plate X.), and connect it with the mine by a tramway. Alongside this loading-stage there would be 15 feet at low water, with a sandy bottom. The ground pegged out has a run on the seams of 3,300 feet. The cost of the ore on ship-board, including amortization of outlay, interest, government taxes, labour, transport and administration, would not exceed 3 pesetas 45 centimos per ton.

3. *Naveces.*—This is a small bay (Fig. 5, Plate X.), to the west of the port of Avilés, sheltered from the effects of the westerly winds by Cape Vidrias, and distant by sea from Avilés about 6 kilometres (3·72 miles).

The veins crop out in the face of the almost vertical precipice forming the coast, from top to bottom, a vertical height of 220 feet, with a dip of 40 degrees from the vertical. Their thicknesses and analyses of samples taken from the weathered outcrops are shown in Table V.

TABLE V.—IRON-ORES OF NAVECES.

Name of Mine.	Thickness of Bed.		Iron Contents.	
			a.	*b.*
	Metres.	Ft. Ins.	Per Cent.	Per Cent.
Upper vein	3·00	9 10	42·23	40·17
Middle „	1·20	3 11	41·97	38·36
Lower „	1·00	3 3	36·90	36·56

Taking the first two beds as workable, there are 959,000 tons above adit-level, after deducting for wastage. Owing to the configuration of the country, the only outlet for these ores is by sea. In order to work them effectively a loading-stage and connecting tramway must be built. Fig. 5, (Plate X.), is a plan of the bay. The cost of the ore per ton, including amortization and interest on outlay, placed on board will not exceed 3 pesetas 50 centimos.

4. *Llumeres.*—The veins in the face of the almost vertical cliffs have been worked during the last 25 years by the owners of the Felguera iron-

works. They have a loading-stage in the small bay of the same name, and steam-barges are carrying the ore to the railway-terminus in Gijon, whence it is taken by rail to their works, situated inland 37 kilometres (23 miles). They work by gallery and stope, the ore costing on board the barges 2 pesetas 75 centimos per ton; the freight allowed to the barges is 1 peseta per ton, and each carries 80 tons. The average assay is 47 per cent. of iron, with silica and other constituents similar to the general assay given.

Adjoining these mines there are others, located upon the run of the veins, which may be considered to be of importance. One of the mines is situated upon the apex of the anticlinal, having the ore in an unbroken flat bed, with only a thin covering of clay-slate and soil. The assay is the same as that of the Felguera mines, but it cannot be worked nowadays, owing to want of means of transport. These have been the object of survey, and a narrow-gauge railway has been planned, to carry the ore to a loading-stage in the Llumeres inlet, which has also been projected. If these plans be carried out, there will be a depth of 36 feet at low water alongside the stage, and the ore can be put on board at a cost of less than 4 pesetas per ton. There are some millions of tons of this ore to be worked. A map of the bay and shipping-station is shown in Fig. 6, (Plate X.). The harbour is sheltered from the effects of westerly winds by Cape Peñas, and there will be no stoppage of loading through bad weather.

5. *Carreño.*—The mines at Carreño are located upon the continuation of the Dormon veins. They have been worked for the last 20 years with an output of about 12,000 tons per annum. The ore is purchased by the Mieres, Felguera and Moreda iron-works. The average assay to-day is lower than when work was first established, due to want of care in separating the thin layer of decomposed slate of about 2 inches thick on either side, wherein the kirving is done. A recent analysis is as follows:—

	Per Cent.
Insoluble residue: Silica	20·47
Peroxide of iron	67·92*
Protoxide of iron	1·84*
Manganese oxide	0·26
Alumina	4·56
Lime	0·42
Phosphoric acid	0·94†
Sulphuric acid	0·53‡
Water and carbonic acid	2·95

* The content in metallic iron is 48·97 per cent. † Equivalent to 0·41 per cent. of phosphorus.
‡ Equivalent to 0·21 per cent. of sulphur.

There is a peculiarity in this district, as there are four veins of ore. The mines have been opened by an adit 1,960 feet in length. The first vein found, 3 feet 3 inches thick (the upper one, and accidental in the series), was found to be lower in iron-percentage than what was considered to be workable ore, and was left unworked. The adit was carried in a further distance of 80 feet, and cut No. 2 vein, with a thickness of 3 feet 7 inches. Galleries were driven right and left in this bed, and stoping followed. The ore from these stopes assayed as follows:—

	Per Cent.
Insoluble residue	15·35
Peroxide of iron	74·91*
Protoxide of iron	0·47*
Manganese oxide	0·20
Alumina	4·27
Lime	0·44
Phosphoric acid	0·88†
Sulphuric acid	0·58‡
Water and carbonic acid	2·76

* The content of metallic iron is 52·80 per cent. † Equivalent to 0·38 per cent. of phosphorus.
‡ Equivalent to 0·23 per cent. of sulphur.

The adit was then driven a further distance of 52 feet, and cut No. 3 vein, 3 feet 3 inches thick, containing ore similar to the preceding. Galleries and stopes were also established in this bed, and work up to to-day has been carried forward in No. 2 vein for a length of 2,100 feet, and in No. 3 for 2,300 feet. No. 4 bed has been proved by surface-workings to have a thickness of 5 feet 3 inches, assaying in iron about 48 per cent. The adit must be driven a further distance of about 110 feet to cut this vein, which to-day is intact. A close estimate of the ore remaining to be worked, after deducting 20 per cent. for wastage, gives slightly over 1,600,000 tons above adit-level. A further back of 100 feet on a run of 13,000 feet by a lower adit should be added to the foregoing, or, say, 1,243,700 tons.

Owing to the length of interior haulage, carried on under the old system of one man one tram, the cost to-day is higher than it should be. This could be materially reduced by the introduction of a mechanical system.

From the dump to the nearest railway station (Veriña) is a distance of 3¾ miles. Bullock-carts take 2 tons each journey, making two journeys per day. The present cost per ton, including cartage to the railway-station, is 4 pesetas 50 centimos. To this loading into truck, the government tax and a proportion of the surface royalty have to be added, say, 1 peseta per ton, making the cost on railway-truck 5 pesetas 50 centimos. By the outlay of the necessary capital to open up

the mines, with a view to a more economical and augmented output, and the laying of a tramway to the new Musel port in Gijon bay, this cost could be reduced to 3 pesetas per ton, provided that 100,000 tons per annum be worked. This price would include amortization and all sundries.

In order to permit the use of the foregoing ores in the blast-furnaces the smelting companies formerly bought ores, low in silica, from Bilbao and Santander, to mix and complete their charges. This to a certain extent has now been altered, as it was found that the addition of the ores from the Bayo district in this province had a similar effect.

This district is situated from 3 to 5 miles south-west of Trubia as the bird flies, where there is a very important government arsenal, turning out heavy guns and projectiles. The railway station of Trubia is 43 kilometres (26·6 miles) from Gijon, and a like distance from the port of Avilés.

Bayo Ores.—The Bayo formation belongs to the Upper Devonian, and comprizes the Old Red Sandstone, with an immense overlay of a close-grained splintery grey limestone. There are very important deposits in this limestone of unfossiliferous blood-red hæmatite of crystalline texture. These deposits fill the fissures and caverns formed by seismic movement, and, so far as can be judged from explorations, appear to underlie the limestone to a certain extent. The deposits carry thin separations and patches of a yellow and white calcite, introduced through breakages after they had been formed. In one mine, now at work, there are thin veins of clean red oxide, so free from silica in grains or other matter that all that has to be done is to grind it in oils to form the celebrated iron paint.

The masses appear to have rich and poor alternating beds, all highly crystalline. The rich is of a purplish colour in the fresh fracture, while the poor ore has a dark red colour. The following are assays of the rich ore :—

Samples.	No. 1. Per Cent.	No. 2. Per Cent.	No. 3. Per Cent.
Iron peroxide	85·680	86·090	86·210
Silica	4·250	4·600	3·730
Phosphorus	0·020	0·033	0·030
Sulphur	traces.	0·004	0·005
Water and carbonic acid...	8·970	8·000	8·000
Metallic iron	59·980	60·260	60·340

A sample of poor ore analysed by Mr. Edward Riley contained :—

	Per Cent.
Silica ...	18·090
Peroxide of iron ...	52·120*
Protoxide of iron ...	0·150
Alumina ...	0·480
Manganese oxide ...	traces.
Lime ...	15·770
Magnesia ...	0·290
Phosphoric acid ...	0·050†
Arsenic acid ...	traces.
Sulphur ...	0·012
Carbonic acid ...	11·840
Moisture ...	1·210

* Equivalent to 36·60 per cent. of metallic iron. † Equivalent to 0·022 per cent. of phosphorus.

The average amount of iron in the ore delivered at the works is about 45 per cent.

The mines are connected with the railway-station by a road that has been carried by easy gradients along the mountain-side. This mountain-range intervenes between the mines and the station, forming a barrier to cart transport by a short route, lengthening the road to 6½ miles, and transport costs from 5 to 5½ pesetas. By installing a self-acting rope-way over the mountain, this cost would be reduced to 1 peseta 50 centimos. Railway transport to Gijon costs 3 pesetas 63 centimos per ton.

The Felguera and Moreda works use this ore in their furnace-charges to the extent of 20 per cent. of the same. The Moreda works imports the balance of their ore-charges from Bilbao and Santander.

The Felguera works in addition to these ores use a magnetic ore from Porcia, which is shipped at the small port of Tapia.

The ores are met with in a number of beds varying in thickness from 3 feet to 14 feet, and run in concordance with the encasing Cambrian slate country. (Parallel to these beds, and at a short distance from them to the west, there is a conformable run of diorite.) In some portions of their run the ores are highly magnetic. All have a blue colour and a slaty fracture, with but slight difference in outward appearance from the slate that accompanies them; but on handling them, the difference in density is at once apparent. They are rich in iron, and contain phosphoric acid, but this does not prevent their use by iron-works who manufacture steel plates and angles from their pig in Siemens-Martin acid furnaces.

A large portion of the manufactured product goes to the government arsenals for shipbuilding purposes, and is subjected to severe tests, which it resists well, thus proving that the phosphorus is eliminated in the various processes to such an extent that it does not affect the results of stresses and strains applied.

The assay of a sample of a general cargo delivered in 1893 to the Felguera iron-works was as follows :—

	Per Cent.
Silica	11·00
Alumina	2·26
Peroxide of iron	74·28*
Manganese peroxide	5·46†
Lime	2·30
Magnesia	0·10
Phosphoric acid	0·92‡
Sulphuric acid	0·19§
Loss in calcining	3·40

* Equivalent to 52 per cent. of iron. † Equivalent to 3·80 per cent. of manganese.
‡ Equivalent to 0·40 per cent. of phosphorus. § Equivalent to 0·10 per cent. of sulphur.

A recent cargo assayed as follows :—

	Per Cent.
Silica	17·70
Alumina	9·35
Iron peroxide...	64·29*
Manganese peroxide	4·31†

* Equivalent to 45 per cent. of iron. † Equivalent to 3 per cent. of manganese.

The difference in the analyses is owing to the workings being at present in a poorer portion of the veins, the way in which these are worked permitting the intermixture of the encasing rock with the ore produced ; and the increase in silica and alumina tends to confirm this opinion.

The ore is at present carted from the mines to Tapia, a distance of 5 kilometres (3·10 miles), and its cost free on board is about 7 pesetas per ton. The freight to the quay at Gijon is 3 pesetas per ton.

There is a small natural harbour within 2 kilometres (1·2 miles) of the present mine, which, with the provision of a tramway and shipping-stage, would reduce the cost on ship-board to 4 pesetas 65 centimos per ton, including all charges.

SUMMARY.

The working of the ores reviewed has been carried on up to the present, only to the extent of supplying the works existing in the district, as there is no exportation.

The Mieres and Felguera iron and steel-works are situated in the heart of the coal-basin. There are batteries of coke-ovens, and the washed small coal costs about 6 pesetas per ton on the works, and limestone costs 2 pesetas per ton.

The Moreda iron-works are situated in Gijon, and fuel is surcharged by railway-transport to the extent of from 3 to 4 pesetas per ton. There are no coke-ovens, coke costs about 20 pesetas per ton on the works, and limestone costs 2·50 pesetas per ton. Against the higher

cost of fuel, the works have the advantage in their favour of the lower cost of the ore delivered at the works, as there are no railway-charges, except for such ore as is transported from the Veriña railway-station, which costs 63 centimos, as compared with 3 pesetas to the other works. The ore used in the blast-furnace is the highest in percentage of iron, and the position of the Moreda works gives them a positive advantage over the others. Further, they have in their favour the proximity of the port for shipment of the finished material without railway charges.

The PRESIDENT moved a vote of thanks to Mr. Jones for his interesting paper, and the motion was cordially approved.

Mr. G. F. Monckton's paper on "The Mining Districts near Kamloop's Lake, British Columbia," was taken as read, as follows :—

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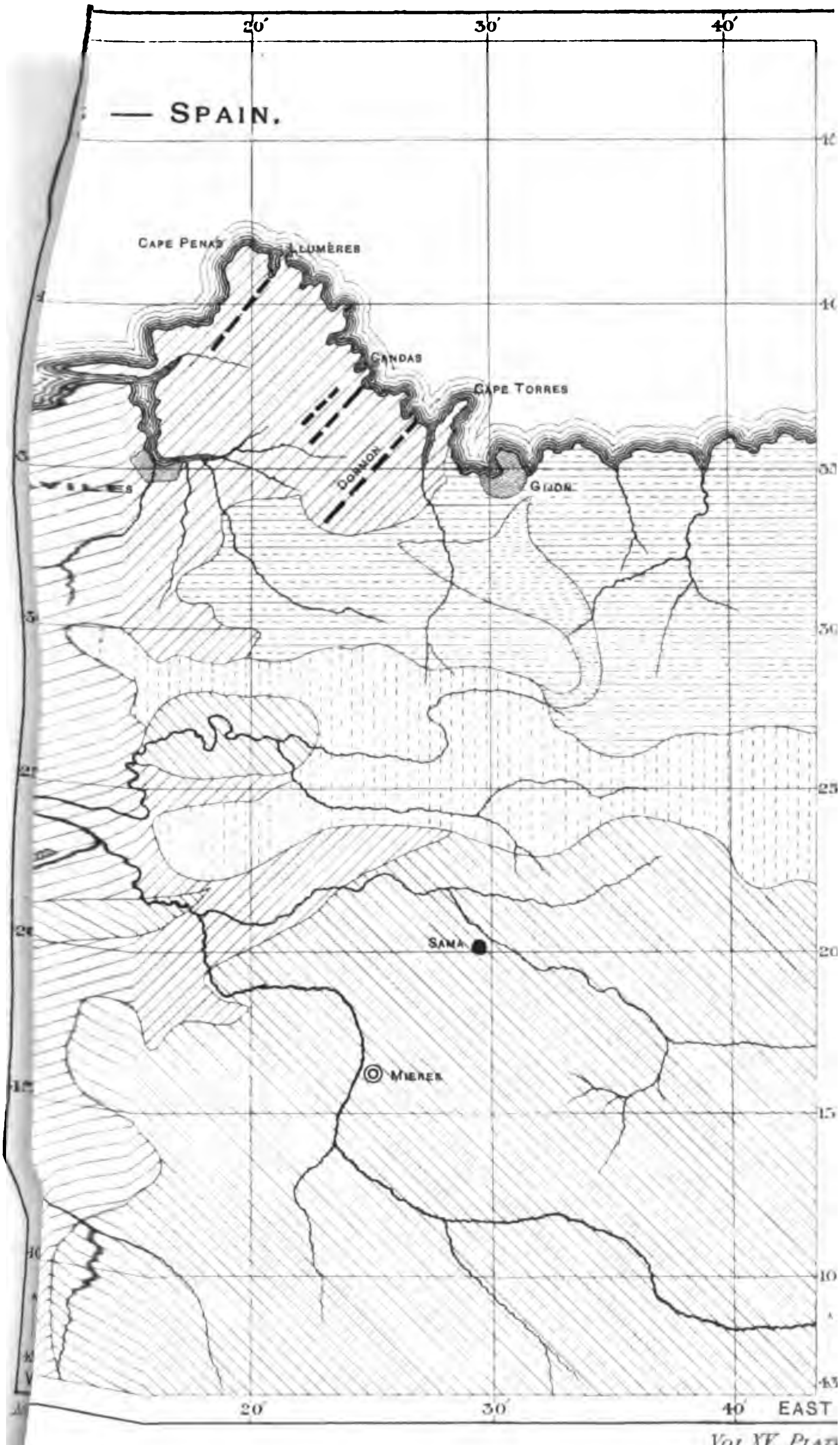

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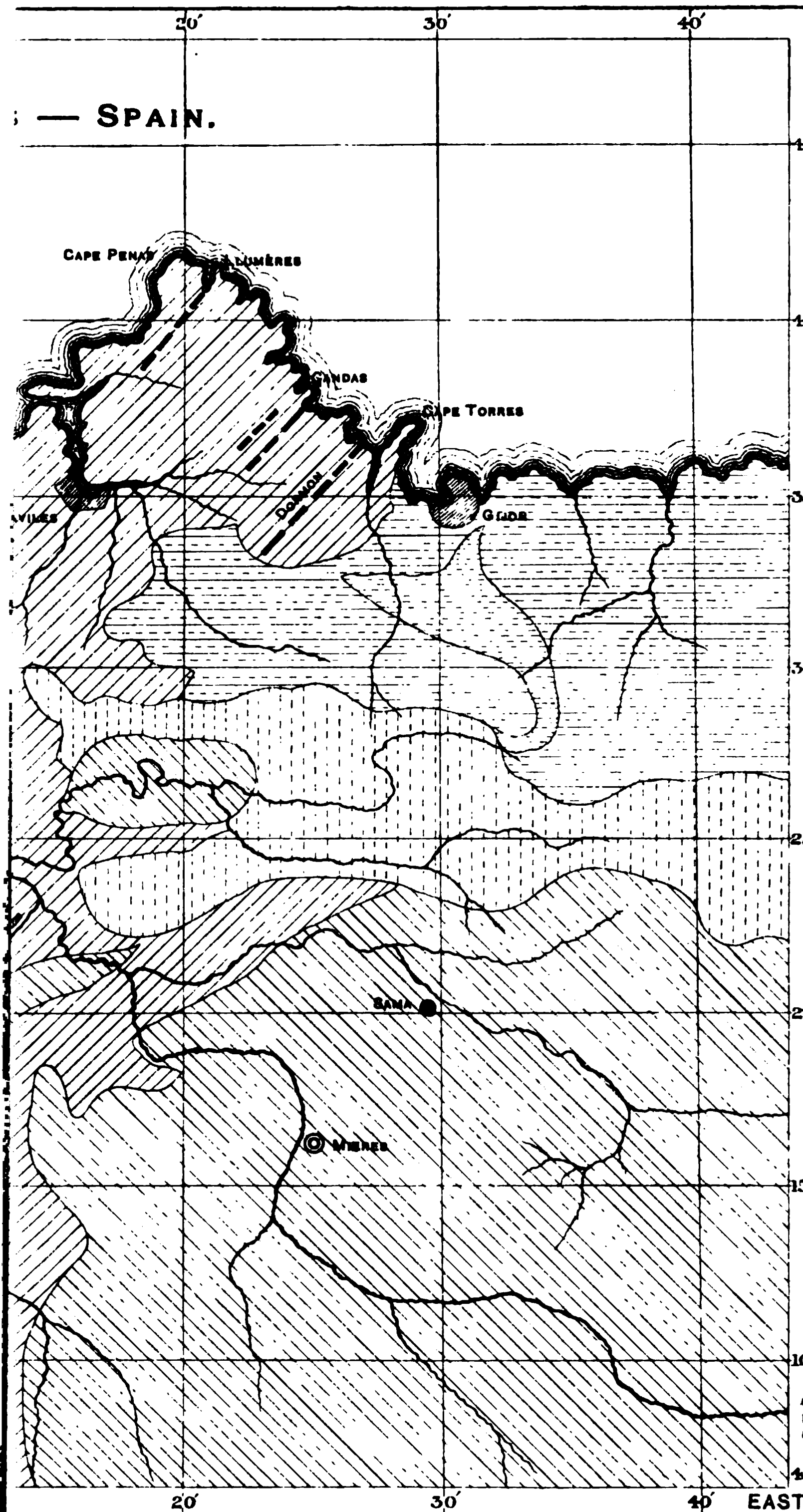
The PRESIDENT moved a vote of thanks to Mr. Jones for hi interesting paper, and the motion was cordially approved.

Mr. G. F. Monckton's paper on "The Mining Districts n Kamloop's Lake, British Columbia," was taken as read, as follows :—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Cape Peñas
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"...n Iron-ores of Asturias, Spain."

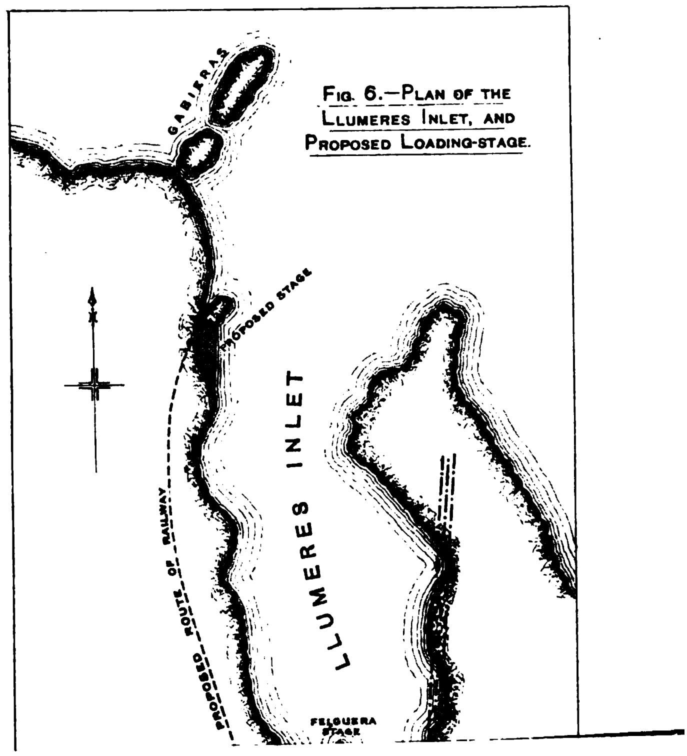


Fig. 6.—Plan of the Llumeres Inlet, and Proposed Loading-stage.

MINING DISTRICTS NEAR KAMLOOPS LAKE, BRITISH COLUMBIA.

BY G. F. MONCKTON

The district of British Columbia to which this paper refers is the western part of the area drained by rivers flowing into Kamloops lake, with an east-and-west width of 35 miles and a length from north to south of 75 miles. It forms a part of the interior plateau, and shares with the rest of that region, which is 100 miles wide, and runs north-

FIG. 8.—VIEW, LOOKING WESTWARD, FROM THE FOOT OF KAMLOOPS LAKE, AT A HEIGHT OF ABOUT 1,200 FEET ABOVE IT. THE COURSE OF THE THOMPSON RIVER IS SHOWN FOR ABOUT 15 MILES. THE DEEP CAÑON, AT THE RIGHT-HAND, ENDING IN A LOWER BENCH, IS THAT OF DEADMAN RIVER. THE BLUFFS, 300 FEET HIGH, ALONG THE THOMPSON RIVER, ARE COMPOSED OF WHITE SILTS MARKING AN OLD LAKE-BED. THE THOMPSON RIVER IS ABOUT 1,000 FEET ABOVE SEA-LEVEL, AND MOUNT GLOSSY, ON THE LEFT-HAND, IS ABOUT 6,000 FEET HIGH.

ward through the whole extent of the province, its peculiar characteristics, namely, a marked want of vegetation in the lowlands, due to the dryness of the climate, and a system of terraced mountains separated by deep narrow valleys (Fig. 8). The rainfall does not exceed 12

inches a year in the lower valleys, which are from 1,100 to 2,000 feet above sea-level; but it is greater on the heights above them. The mountains are usually thinly wooded, and contain many large open areas covered with grass, which make this region a great cattle country. All the higher ground is dotted with alkali lakes. The summer is very hot, grapes and water-melons growing luxuriantly in the open air, while the winter is very cold, $-10°$ Fahr. being no uncommon temperature. The clearness and dryness of the atmosphere has caused the district to be a favourite resort for consumptives.

The greater part of the region may be said to be unexplored, as with the exception of a rough survey made by the Geological Survey Department, it has not been mapped, and is untravelled even by the cowboy and the Indian. Comparatively little development has yet been done in the district, as the local capital available is but small, Kamloops, the only town in the district, having a population of 1,500, while the other central point, Savona, is a very small settlement. It must be admitted that the people of Kamloops have not done badly with the means that they had at their disposal. The region has been the happy hunting-ground of the heaven-born mining expert, who can scarcely read or write, who last year was a grocer, and next year, by a process of natural selection, will become a vendor of tin cans, but who for the nonce, by means of a long tongue which he can twist round the longest words to be found in the dictionary of mineralogy, is able to confound the men of slower intellects.

The progress of the district has been also greatly hampered by the continual restaking of claims without doing any work upon them. This is rendered possible by the law which allows 12 months in which to do the assessment-work and permits the transfer of the claim before it is done. Miles of rich mineral country are thus tied up. When the mining excitement first began in Kamloops, the saw-mills did a good business sawing location-stakes, which must square 4 inches and stand 4 feet high. On Sundays, a procession of carriages loaded with these stakes might be seen wending its way out to the nearest mineral region, over which carriages can be easily driven. As soon as a rock was seen, a stake or collection of rival stakes was set up on it. In those days, a man was poor indeed who did not own a dozen claims or more. As the expected capitalists did not come along to buy these claims, most of the claims have lapsed, and their locators have sought their way to wealth in some harder way.

GEOLOGY.

The geological formation of the district may be briefly described as follows:—The Cambrian is believed to be represented by a limited area of shales and slate near Campbell creek. To the Carboniferous system belongs a series of schists, limestones, conglomerates, and sandstones interstratified with trap, which occurs along the North Thompson river. The Nicola group of the Triassic formation covers a very large portion of the district, and is composed almost entirely of volcanic ash and trap aggregating 15,000 feet in thickness. A few beds of shale and limestone are found in this series. The Tertiary (Oligocene and Miscene) formation is largely represented, first by the Coldwater beds, which are chiefly conglomerates, laid down during an interval of quietude between periods of volcanic disturbance, then by a series of beds of dolerite and porphyry, a group of bedded tuffs known as the Tranquille beds, and finally a series of basalts and conglomerates. Several areas of plutonic rocks occur within the compass of the map (Fig. 2, Plate XII.), and all of those which have been prospected have been found to contain or be connected with the occurrence of metalliferous deposits. The probability of this was pointed out by Dr. G. M. Dawson in a report of the Geological Survey.* These rocks are gabbros, diorites, and granites. Some of them are believed to be of Tertiary age. All these older rocks are overlain by Glacial Drift, and there is a remarkable series of finely bedded silts, which were evidently deposited in a deep lake-basin as the glaciers retreated. The traces of glacial action are very marked in the district. The whole region has been subjected to great volcanic disturbance in Triassic and Tertiary times. Among the chief centres from which the volcanic *débris* was distributed are Skoatl Mountain, Porcupine Ridge, and Battle Bluff. From this preliminary statement, the writer will proceed to the actual occurrences of minerals in the district.

COAL-FIELDS.

The two coal-bearing areas of this district are those of the Tranquille beds on the north end of the lake and the North Thompson river. This latter is in the north-eastern corner of the map (Fig. 1, Plate XI.), and is likely to have an important bearing on the future of the district. It is a trough in the older rocks occupied by Tertiary beds, and is

* "Report on the Area of the Kamloops Map-sheet, British Columbia." By Dr. George M. Dawson. *Annual Report of the Geological Surveg of Canada*, New Series, 1894, vol. vii., Report B, pages 1-427.

largely covered by Drift, occupying only a small area. The beds form a syncline, and some of them have been exposed by Coal brook, which intersects them. There are numerous coal-seams averaging 1 foot in thickness, and showing considerable regularity. Where these beds are exposed the dip varies from 12 to 15 degrees. The rocks accompanying the coal are shales, clays and sandstones, such as are usually found in coal-formations. According to the report of the Canadian Geological Survey, a tunnel run in a seam showed the following section :—

	Feet.	Inches.
Coal	0	6
Sandstone	2	0
Coal	0	9
Sandstone	0	6
Coal	1	6

An underlying seam of coal is reported. The analysis showed by slow coking 2·22 per cent. of water, 32·05 per cent. of volatile matter, 52·81 per cent. of fixed carbon, and 12·92 per cent. of ash. This coal should be worked to a profit in view of the high price of coal throughout the district, as it could be transported by water to Kamloops and thence conveyed down the lake 25 miles westward, or carried on the South Thompson river 80 miles eastward to the head of Shuswaf lake. The coal-seams of the Tranquille beds are only exposed at one point, at Guerin, south of Kamloops, although they are believed to cover about 30 square miles. At Guerin, several seams crop out in the banks of a brook, and an incline has been sunk in them which showed seven seams of coal aggregating 2 feet 6 inches in a total thickness of 6 feet 10 inches (Fig. 4, Plate XIII.). It will be seen that the number of dirt-partings render this seam of small value. More small coal-seams occur here, but the value of the coal-field can only be ascertained by borings at different points. The western end of the Tranquille beds has been so disturbed that no coal-seams are likely to be found there, but the mouth of the Tranquille river and the southern side of the flats at the head of the lake would be good locations for bore-holes. Beds of the series occur again 18 miles south of Kamloops, in which coal may be found. It is much to be desired for the sake of the district that some portion of these coal-areas will be successively developed, as coke for smelting purposes might then be obtained at a reasonable rate. Fine clay occurs in the Tranquille beds.

Metalliferous Areas.

Stump Lake.—About 25 miles south of Kamloops (Fig. 2, Plate XII.) occurs an area, covering about 15 square miles, in which are

found some veins that are likely to become of considerable importance. The country-rock is a green diabase-porphyry with some interbedded diabase-tuffs and felspathic rock. These rocks are usually much decomposed where the veins traverse them, and are reddened by iron-pyrites and dolomite. The vein-material is white quartz, carrying iron-pyrites, galena, copper-pyrites and grey copper. The ore of the Planet mine is quartz, containing copper-pyrites and galena, into which brown spar and chalcedony have been introduced, probably in the time of the Tertiary volcanic activity.* The chief value is silver, with which is associated some gold. The work on these claims was done more than 10 years ago, when it was suspended owing to the difficulties of transport. These will be overcome as the country becomes more settled. Several shafts attained a considerable depth, notably the Joshua, 400 feet, the Tubal Cain, 220 feet, and the King William, 175 feet. Others exceeded 100 feet. The Joshua mine had 745 feet of levels, and the Tubal Cain mine 1,350 feet. The Joshua vein varied from 10 inches to 5 feet wide, was nearly vertical, and ran north 10 degrees west, that of the Tubal Cain dipping at an angle of 60 degrees eastward, and having a strike of north 5 degrees west. The King William vein strikes north 10 degrees west, and has a very steep dip to the east. The Star lode averages 3 feet in width, dips at an angle of 60 degrees eastward, and runs north 5 degrees west. The direction of the Planet vein is north 10 degrees east, and it dips eastward. With very few exceptions, the lodes of this camp have a similar dip and strike.

Jamieson Creek.—Here occurs (Fig. 1, Plate XI.) an area of granite in the Palæozoic slates. This, like most of the plutonic intrusions in the area under consideration, contains metalliferous veins which pass into the adjoining slates. These lodes are quartz carrying pyrites, galena, zinc-blende, and grey copper. The granite is largely decomposed, and is grey, except where the associated iron-pyrites has oxidized and coloured it red. The veins for the most part run north and south. Many of them are 6 and 10 feet wide. Tests made on ore from four of them for the Canadian Geological Survey, showed 11 dwts. to 1 ounce 2 dwts. of gold, and from 2·5 to 34·2 ounces of silver per ton. According to Dr. G. M. Dawson, the lodes were probably contemporaneous, or nearly so, with the intrusion of the granite. The dip of the lodes is nearly vertical. It is probable from the results of preliminary prospecting that this district will be found to contain many large bodies of low-

* *Annual Report of the Geological Survey of Canada*, New Series, 1894, vol. vii., Report B, page 335.

grade ore. Most of the properties are at an elevation of 1,500 feet above the North Thompson river. The district can be reached by water or by waggon-road from Kamloops, from which it is distant 15 miles, but although it is so convenient of access, little work has yet been done.

Coal Hill.—Several claims lie along the northern slope of Coal Hill which is immediately south of Kamloops (Fig. 1, Plate XI.). The principal ones are the Iron Mask and the Python. The first is situated at the north-eastern corner of the ridge, which is composed of gabbros and diorites. It is the only claim on the hill from which any considerable amount of ore has been shipped, 3 carloads of 20 tons each having been sent out. Two of these were of picked ore and yielded respectively 19 ounces of gold, 1·30 ounces of silver, and 16 per cent. of copper; and 22 ounces of gold, 1 ounce of silver, and 14·29 per cent. of copper. The third shipment of average ore contained 0·06 ounce of gold, 0·60 ounce of silver and 11·75 per cent. of copper. The vein is on the steep side of the mountain, and is opened by an adit-level. It has a total thicknesss of 4 feet, the paystreak being about 1 foot wide. The ore is copper-pyrites and magnetite. Other copper-ores occur. On the foot-wall is a seam of calcareous schist. The vein was but little exposed on the surface.

The Python mine lies 2 miles east-south-east of this property (Fig. 4, Plate XIII.). The lode has a direction of east 15 degrees south, and is believed to be the same as that found in the Charlotte, 2 miles east, and intervening claims. It has been opened by a shaft 55 feet deep and a drift at the bottom. In the shaft, the vein is over 8 feet wide, the northern wall not having been found. Although a slickensided face of rock occurs on the southern side it is doubtful whether that is really a wall, it being in the writer's opinion only the side of a dyke running parallel to the vein; south of this is found a cross vein running about north-east. This carries some copper. In a surface cross-cut a few hundred feet from the shaft may be seen the whole width of the vein which is 30 feet wide at that point, and is much oxidized. On this property, the lode has been traced over 2,000 feet in length. There is a fine opportunity for working the claims by an adit, as a level can be driven to intersect the vein at a depth of 600 feet, and this need only be 1,000 feet long. The present company are driving an adit 200 feet down, and if the property shows up well they will then drive the deeper level. There is another cross-vein carrying copper which is east of and parallel to the first. The vein is intersected by numerous barren veins thrown out from parallel dykes, but one-half of the material composing

it could be hand-picked and would average about 10 per cent. of copper. The metal occurs chiefly as copper-pyrites, but much carbonate-ore is found near the surface (Figs. 9, 10 and 11).

Between this mine and the Charlotte of the Kimberley group are several promising claims. There are some veins of magnetite on the Calumet. These run north. There is a shallow shaft and open-cut on the Charlotte, in which is exposed an ore-body resembling that of the Python, and not less than 15 feet wide. An adit is being driven to intersect this and will reach it at a depth of 85 feet. As the adit will be considerably over 200 feet long this is not a very satisfactory operation. The drift would not have been much longer if it had been put in 100 feet lower down.

FIG. 9.—VIEW, LOOKING WESTWARD, FROM THE PYTHON MINE, ON COAL HILL. THE PYTHON MINE BUILDING IS ON THE LEFT-HAND; THE CONCENTRATOR WILL BE BUILT ON THE LAKE IN THE FORE-GROUND; AND THE VALLEY IS COMPOSED OF THE TERTIARY COAL SERIES, WHICH ARE COVERED BY VOLCANIC LAVAS, COMPOSING THE HILLS ON THE RIGHT-HAND. THE DISTANT VALLEY ON THE LEFT-HAND IS KAMLOOPS LAKE, IN THE CENTRE IS THE TRANQUILLE RIVER, AND ON THE RIGHT-HAND IS THE BEGINNING OF THE NORTH THOMPSON VALLEY.

On Coal Hill, between the Python and Iron Mask, are several claims on which work has been done. On the Golden Star, mispickel and copper-pyrites occur in diorite. This property has been opened by a surface-drift and a shaft, the latter sunk on the edge of a small lake which runs into it. As the water pumped from the shaft will run into the lake and thence return with all possible celerity to the shaft, it would seem as if the workers on this shaft would solve the secret of perpetual motion.

In a flat just above the Iron Mask lies the Lucky Strike, the property of a British syndicate, but as the vein deteriorated it was abandoned at the depth of 75 feet. Seeing that there is a good deal of fine ore on the surface, and that the vein has been found for a considerable distance on the surface, it is rather surprising that they have let it lie idle so long. The lode may be expected to run through the Neighbour claims to the south, where similar ore has been found.

In the Phœnix and Bluebird immediately north, copper-pyrites is found in schistose rock.

Two miles east of the Iron Mask is the Pothook group, which is being worked by The Scottish Mining Syndicate, Limited. There are

FIG. 10.—VIEW OF SHAFT OF THE PYTHON MINE.

outcrops of copper at several points on this property, but the main expenditure is being made in an irregular body of altered rock which may be classed as a serpentine and lies along a line of fissuring, through which, no doubt, ascended the vapours generated during the intrusion of the dykes which are in contact close to this. This ore-body is of great width and contains native copper, at some points in considerable amounts, but as a rule it will not average over 1 per cent. Some bornite also occurs. A shaft is being sunk to a depth of 350 feet, and levels are being driven at depths of 80, 170 and 250 feet. The management hope to find a rich streak in this deposit and may do so, but

it seems at present more likely to turn out a low-grade proposition. A large proportion of the ore already in sight might, perhaps, by careful handling, be made to pay by concentration.

On this group and some adjoining claims, notably the Dakota and Dawson, are found lodes of magnetic iron, which at some points have a width of 40 feet. These are probably the cappings of copper deposits, and in fact in the two claims mentioned the magnetite shows some copper in the shallow shafts sunk. The writer is inclined to think that these iron veins will prove eventually to be the main dependence of this part of the camp. There are many other claims in this locality

FIG. 11.—VIEW OF FOOT OF INCLINED TRAMWAY FROM THE PYTHON MINE.

which promise well but are not of sufficient importance to detail now, and the properties which next come under review are those of Cherry Bluff.

Cherry Bluff.—In this area of diorite and gabbro which borders on Kamloops lake are two properties of note, the Copper King and the Glen iron-mine (Fig. 1, Plate XI.). The first of these is nearly at the western end of the bluff on the southern side. It consists of a zone of granite impregnated with iron- and copper-pyrites which runs north and south, and is about 30 feet wide. The paystreak lies alongside a small vein of

limestone which carries copper. At the western end of the bluff are many small veins of specular iron traversing the gabbros and mica-diorites which compose the mountain. Here also occur some large bodies of magnetite having an east-and-west strike and dipping to the north. Although much faulted, they have many of the characteristics of true veins. The main deposits known are (1) a mass, level with the railroad-track, from which 2,000 tons have been taken. This has been sunk on to the level of the lake. (2) An opening west of this, where a vein 2 to 5 feet wide has been worked. (3) A deposit of ore 10 feet wide, from which a good deal of ore has been shipped. A former superintendent shipped out several hundred tons of country-rock to the smelter from this point. It was not appreciated by the furnacemen at all, and was eventually dumped out for ballast. (4) Almost on the summit of the hill crop out several parallel veins, of which one is the chief source of supply. The ore is quarried out of the floor of a long cut. In the upper workings on this deposit there is 8 feet of first-class and 7 feet of second-class ore. This vein is faulted to the south at the western end of the cut, the foot-wall becoming the hanging-wall. Thereafter it appears to split up into two veins, which widen as they go west, but apparently deteriorate in grade, the width of country-rock and vein being about 300 feet, of which 10 per cent. is iron. At one point, a bluff of high-grade magnetite, 20 feet high is seen. Besides these ore-bodies, other large masses crop out both west and east, but no work has been done on them yet. The ore for which contracts are taken has to average 50 per cent. of metallic iron and upwards. It thus happens that the dump is largely composed of 40 per cent. magnetite, and much fine ore is left in place. There is an aerial tramway in operation here (Fig. 12). The total output of the mine has not exceeded 10,000 tons, the demand being small, as the country cannot yet support iron-furnaces and the smelting works which use the ore as a flux in smelting lead-ores are 400 miles distant. At a low computation, there is actually in sight 100,000 tons of 45 per cent. magnetite. An adit is being driven to intersect the larger ore-bodies at a depth of 600 feet, which it will reach at 385 feet from its present termination if they continue in a regular manner to that depth. Assays of three samples are appended:—

Oswego Ironworks, U.S.A.	(1.) Per Cent.	(2.) Per Cent.
Iron	67·250	64·970
Silica	2·040	4·810
Phosphorus ...	0·258	0·155
Sulphur	0·232	0·182

Trail Smelter, B.C.	(3.) Per Cent.
Iron	62·10
Silica	4·00
	Ounce.
Gold	0·02

Due north of this mine lie the Trent and some other claims in which copper occurs in the same kind of rocks, which at one period were evidently united to those of Cherry Bluff. Cinnabar and copper also occur there in dolomite. The granite, wherever it carries copper, is considerably altered and traversed by veins of dolomite and lime. On the Trent claim, the principal deposits of copper seem to run irregularly through zones of decomposed granite, which are heavily charged with iron-pyrites. The strike is north and south, the dip being nearly vertical, and their character is somewhat altered where they are crossed by the calcareous veins, which lie nearly flat (Fig. 5, Plate XIII.).

FIG. 12.—VIEW OF AERIAL CABLE-WAY OF THE GLEN IRON-MINE.

Before leaving this area of gabbros and diorites, the writer may say that it would seem as if all the ore-deposits in them are veins of replacement, the vein-filling of which has been deposited by thermal waters rising along the line of fissures in the gabbro and kindred rocks. These waters would replace the calcareous components of the country-rock by oxides of iron, which were probably derived from the pyroxene of the same rocks. The copper would be obtained from volcanic rocks in the district. Hornblende and labradorite would provide a large quantity of lime, and would thus be largely the source of the calcareous veins. Magne-

tite occurs in grains disseminated through the rocks of Cherry Bluff. The veins usually have one well defined wall, which is the line of the original fissure through which the heated vapours ascended, one wall being indistinct, and the scanty evidence which we have before us at present gives reason to believe that the ore will often be found to cross over to the other side of the wall, as the solutions found it easier to decompose the rock on that side of the fissure. One such well marked instance may be seen at the Glen iron-mine. The writer may say, however, that there are other theories. One old miner has informed him that the mountains are hollow, and that the metalliferous solutions are still boiling and "sizzling" inside. We have not as yet sunk or drifted far enough to prove the truth of this opinion, but perhaps some "bloated capitalist" in the old country will undertake this somewhat dangerous operation. If these subterranean furnaces could be safely tapped, we should have another source of heat for industrial purposes.

Copper Creek.—The developments on Coal Hill and Cherry Bluff have not so far afforded us sufficient data for forming theories as to the influence exerted on the formation of ore-bodies by different rocks and contacts, and this in some degree detracts from the interest that scientific men would take in those areas. This is not, however, the case with the Copper Creek district. Here it is well seen what are the rocks affecting the deposition of ores, and it seems as if any work done along certain contacts which are barren when first attacked will show up ore, although not necessarily in paying quantities. The writer will deal first with the copper-ores of the district, as the consideration of the phenomena attendant on the occurrence of cinnabar will lead us further afield. The portion of the district carrying copper-ores is a small one, lying immediately east of Copper Creek and forming Lookout Point, 850 feet above the lake (Fig. 3, Plate XII., and Fig. 6, Plate XIII.). The extent of it is about 1 square mile. Copper is known outside of this, but no deposits of note have been found. The formation is of Tertiary age, and originally consisted of stratified tuffs and arkose, the greater part of which belongs to the Tranquille beds. These are intersected by dykes and sheets of basalt and porphyry. The tuffs have been so contorted that their dips and strikes vary every few feet. Through them a dyke of augite-porphyry has been thrust. Its direction is nearly north, its dip almost vertical and to the east. It throws out some smaller dykes running nearly at right angles. Its thickness will average 800 feet. This dyke, as well as the beds of ash,

is intersected by a sheet of basalt, dipping 45 degrees east and throwing out numerous vertical or nearly vertical dykes. This basalt is the ore-bearer of the camp. The ore-bodies of importance, so far as known, are all actually upon or close to the contact of the basalt and porphyry. The basalt itself carries some copper at almost every point. Both of these rocks carry the metal at the contact, distinct veins of quartz in them being of very secondary importance. The porphyry is traversed by numerous similar small veins, usually carrying grey copper.

The principal work has been done on the El Progreso and Tenderfoot claims. In both these areas, ore is being followed which lies along the contact of the basalt and porphyry. That in the porphyry is bornite, while much of that in the basalt is copper-pyrites. One of the principal paystreaks is a narrow dyke of basalt which has been shattered and re-cemented with calcareous veinlets (Fig. 7, Plate XIII.). The El Progreso carries a good proportion of gold, while 4 tons shipped from a 6 inches vein of dolomite in the Tenderfoot claim yielded 21·97 per cent. of copper and some gold and silver. In the El Ultimo, a dyke carries bornite where it is traversed by quartz-veins. In the Caledonia, a decomposed dyke holds some native copper. The composition of this is probably peridotite, but it is so rotten that this is not easily ascertained. In the gulch below, much native copper occurs from the denudation of this. No doubt this is where the Indians obtained their copper, on account of which they called the stream hard by Copper creek. The dyke does not seem to contain any appreciable quantity of the metal now.

Near this, on the Last Chance, is a quartz-vein containing molybdenite associated with copper-pyrites. The copper of this area is no doubt derived from the underlying Nicola rocks, as they are traversed by numerous small veins of copper-pyrites of high grade, the metal in which was gathered up by the heated waters attending the intrusion of the basalt and porphyry, and deposited in the fissures opened in them during the period of their cooling. It is very likely that the disturbances which resulted in the production of granite eastward of the creek had partially concentrated the copper previous to the intrusion of these volcanic rocks. There is reason to suppose that this granite belongs to the end of the Nicola period. This would explain why the metal is only found in appreciable quantities over such a limited area. Nearly all the later Tertiary dykes in this area contain some copper.

Copper occurs west of Mamit lake (Fig. 2, Plate XII.) in black basaltic rock at its contact with porphyry. Shipments have yielded 9

per cent., and it seems to be irregularly distributed through the rock. The surface-soil is very heavy in that locality. It also occurs on Criss creek and Deadman river, and Jacko lake on the south side of the granitic area of Coal hill seems to be destined to take a prominent place in the mining industry. Intrusive volcanic rocks of later date are there in contact with the gabbros. It is noteworthy that nearly all the deposits of copper are near outcrops of the Tranquille ash-beds.

On the west side of Copper creek* is a zone of dolomites and porphyries which overlie the Coldwater (Oligocene) conglomerates (Fig. 3, Plate XII.). In irregular quartz-and calcite-veins through these cinnabar is found. The general direction of the veins is north and south. Cinnabar is found in the country-rock as well as in the veins. A considerable sum has been spent at the mouth of the creek in mining in these rocks but without success. A furnace was built to treat the low-grade ore, with the result that one may now wash quicksilver in the creek below it. Parallel levels were driven into the mountain-side, and the works now resemble a huge rabbit-warren. Under the earlier management they produced 7,865 lbs. of quicksilver from high-grade ore. This quicksilver zone extends for a great distance, crossing Copper creek higher up, where it is again found to contain cinnabar at Hardy mountain. In that locality it occurs disseminated in dolomite and in an altered rock which appears to be volcanic ash, also in rich little veins traversing these, and in the channels of extinct hot springs. The best ore is a brecciated quartz cemented with lime.

On this same zone, cinnabar was discovered by Mr. A. J. Colquhoun at Toonkwa lake last year. This place is 12 miles south of Savona. There is but little rock showing, but the zone appears to be of considerable width. Between these two, near Kamloops lake, dolomite and dolomitized rocks about 1,000 feet wide are seen at several points to carry cinnabar. Throughout the upper part of the Nicola (Triassic) series, especially near the western end of Kamloops lake, a little cinnabar may be found.

North of Copper creek, on Criss creek and Deadman river, cinnabar occurs in the Tertiaries, and there seems to be a most promising district about 3 miles up Criss creek, where the zone of cinnabar-bearing dolomites runs north-west and lies near granite. This zone lies west of the other, but may be the same one faulted. It is noteworthy that the Copper creek zone has at one end two small areas of granite and in the immediate neighbourhood of Hardy mountain mines another granitic

* *Trans. Inst. M.E.*, vol. xiii., page 592, Mr. H. Merritt on the "Occurrence of Cinnabar in British Columbia."

area. In the granite of Copper creek some cinnabar occurs. Near the Trent mine, cinnabar is found in dolomite close to another granite-area.

The dolomites containing cinnabar have been traced by Mr. Colquhoun 10 miles north of their occurrence on Criss creek. These dolomites may be in part the result of alteration of other rocks, but would seem from their permanence and the fact that they coincide with the line of strike and dip of the bedded rocks of the district, to be in part at least a sedimentary formation. The strata of the district are throughout so heavily faulted that it is extremely difficult to classify them. The work of the Geological Survey in this district is very rough, (probably on account of the great area to be traversed by a very small party), especially in the outlying districts, Criss creek, for instance, but it affords a good groundwork on which to base observations.

About 10 miles up the Criss creek, a new mineral district is being developed at Skomallus (an Indian word meaning an "open space"). The mineral is found near to the contact of the sandstones, limestones and conglomerates of the Coldwater series with a mass of granite. The principal deposit is that of the Mersey mine, where for 100 feet in width the stratified rocks near the contact are traversed by small quartz and lime veins running north. These carry zinc-blende, galena and copper-pyrites, the first prevailing on the eastern side, and galena in the centre. The talcose quartz between them carries iron-pyrites. Fifteen feet on the eastern side yield from 15 to 26 dwts. of gold per ton and a little silver. On the extreme eastern side, a 2 feet vein of quartz carries over 1 ounce of gold per ton. This ore-body is exposed in the river-bed and on the banks, and is now being developed. There are many other lodes in the locality, notably some of quartz with mispickel which are 20 feet wide, but not yet found to be of value (Fig. 13).

In conclusion, the writer may say that while this district is new and but little work has been done it should come into prominence rapidly as development is pushed, transportation being so easily available. The cost of mining will, of course, vary with the rock, but sinking a 9 feet by 5 feet shaft costs £3 per foot in dolomite, £4 in porphyries and gabbros, and £7 in basalts and the harder granites. Drifting costs per foot in dolomite, 16s.; in porphyries and gabbros, £1; in basalts and granites, £2. Treatment calls for an expenditure of £2 10s. per ton, including freight, in the case of copper-ores which have to be shipped 400 miles, and the copper is paid for at three-fifths the market price. Cinnabar-ore should be treated for 4s. per ton so that 0·1 per cent. should pay for treatment at present prices.

CONGLOMERATES AND PLACERS.

In addition to deposits of metallic minerals in veins, gold is found within this area in conglomerates of Tertiary age, and also in gravel which in part dates from the Glacial Epoch, but is for the most part more modern and caps the river terraces.

The conglomerates have been but little tested, but would probably be well worth investigating, as they have been found to carry gold at several points and could be quarried for milling at a very slight expenditure. The gold would be free, so that the ore should not cost more than 2s. per ton to mill. It must, however, be pointed out that much prospecting and

FIG. 13.—VIEW OF THE FIRST MINER'S CAMP AT SKOMALLUS.

testing would be necessary before proceeding to deal with them. Some of the conglomerates have been much altered by the heat of the volcanic intrusions which have broken into them, and the writer would suppose that would be the best to test, as the gold might be collected into paystreaks. The conglomerates attain an enormous width at certain points.

Placer-gold has been found on the Tranquille river, which is believed to have yielded a very considerable sum, and on Criss creek, where the conglomerates are supposed to have been its source (as to this the writer has great doubts), on Jamieson creek, and on the Thompson river below Kamloops lake. In all these cases it is confined to thin paystreaks, rarely exceeding 6 inches in thickness, and is not likely to furnish a large

output in the future. Many other streams will yield a prospect, but not sufficient to pay interest on the capital expended in purchasing a pan, and a man does well if he can make 6s. a day in the season of low water. A new paystreak, which promised satisfactory results, had recently been found in Criss creek, laying upon the bed-rock; while the deposits, previously worked, lay several feet above it (Fig. 14).

When the mines are more developed, which will be in about a year's time, the writer will endeavour to show the results of the work in

FIG. 14.—CLEANING-UP ON A PLACER-CLAIM.

a paper supplementary to this. Work is the only thing that will make mines.

Accompanying the paper is a reduced plan of part of the Canadian Geological Survey map, an enlargement by the author of the district immediately contiguous to Kamloops lake, and other plans and sections.

The writer's best thanks are due to several gentlemen for assistance given him when he was inspecting properties for the purpose of writing this paper, more especially to Mr. Wentworth F. Wood, assayer, Kamloops, and Mr. A. J. Colquhoun, mining-engineer, who has made a special study of the cinnabar-occurrences.

The CHAIRMAN moved a vote of thanks to Mr. G. F. Monckton for his valuable paper, and the resolution was cordially adopted.

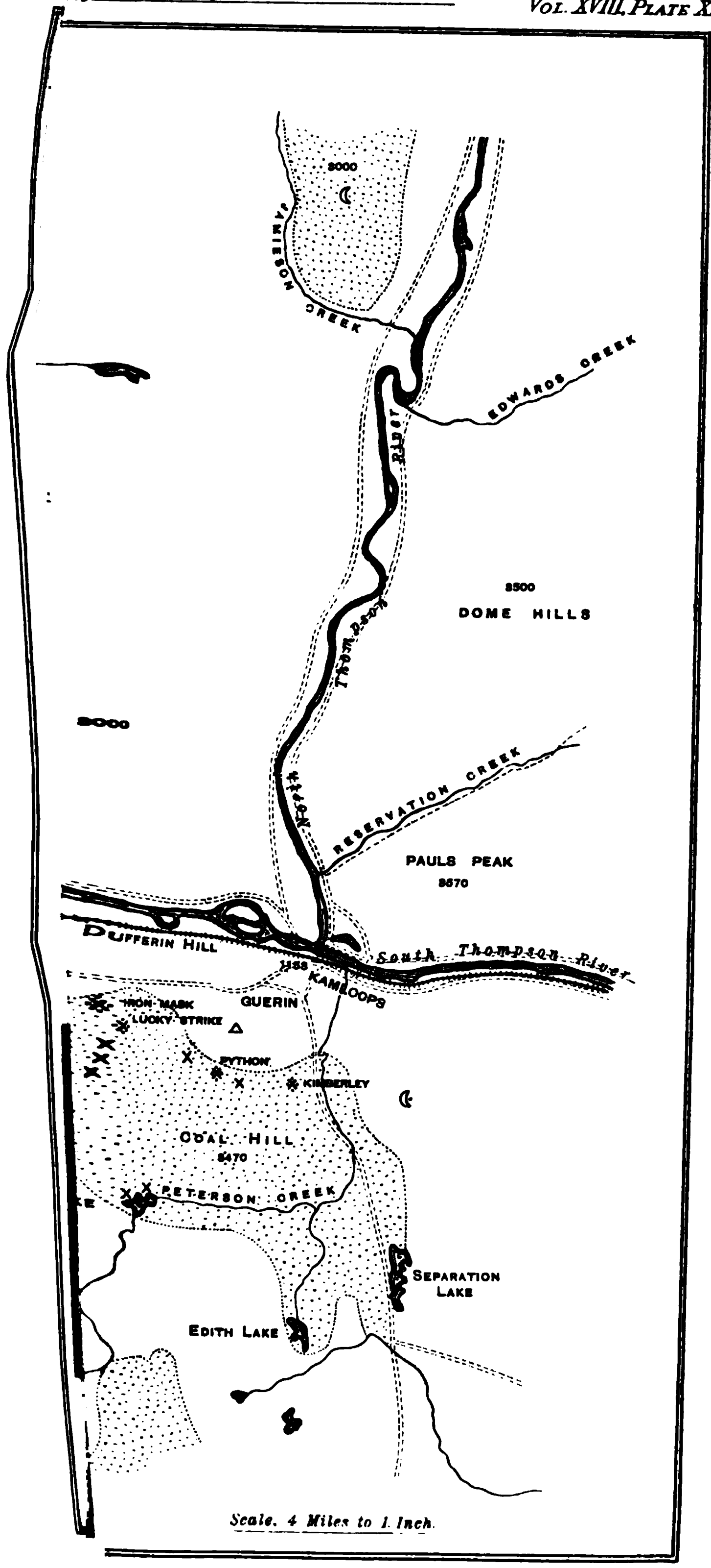
Mr. GEORGE LEWIS (Derby) moved that the thanks of the members be accorded to the Reception Committee of the Midland Institute of Mining, Civil and Mechanical Engineers, to the President and Council of the University College, Sheffield, to Messrs. William Cook & Co., Limited, Messrs. John Brown & Co., Limited, the Denaby and Cadeby Main Colliery Company, Limited, and Hadfield's Steel Foundry Company, Limited, for having opened their works and collieries for the inspection of the members, and to Mr. J. A. Longden and Mr. W. D. Holford for kindly arranging for an excursion of the members to Castleton.

Mr. M. WALTON BROWN seconded the resolution, which was cordially adopted.

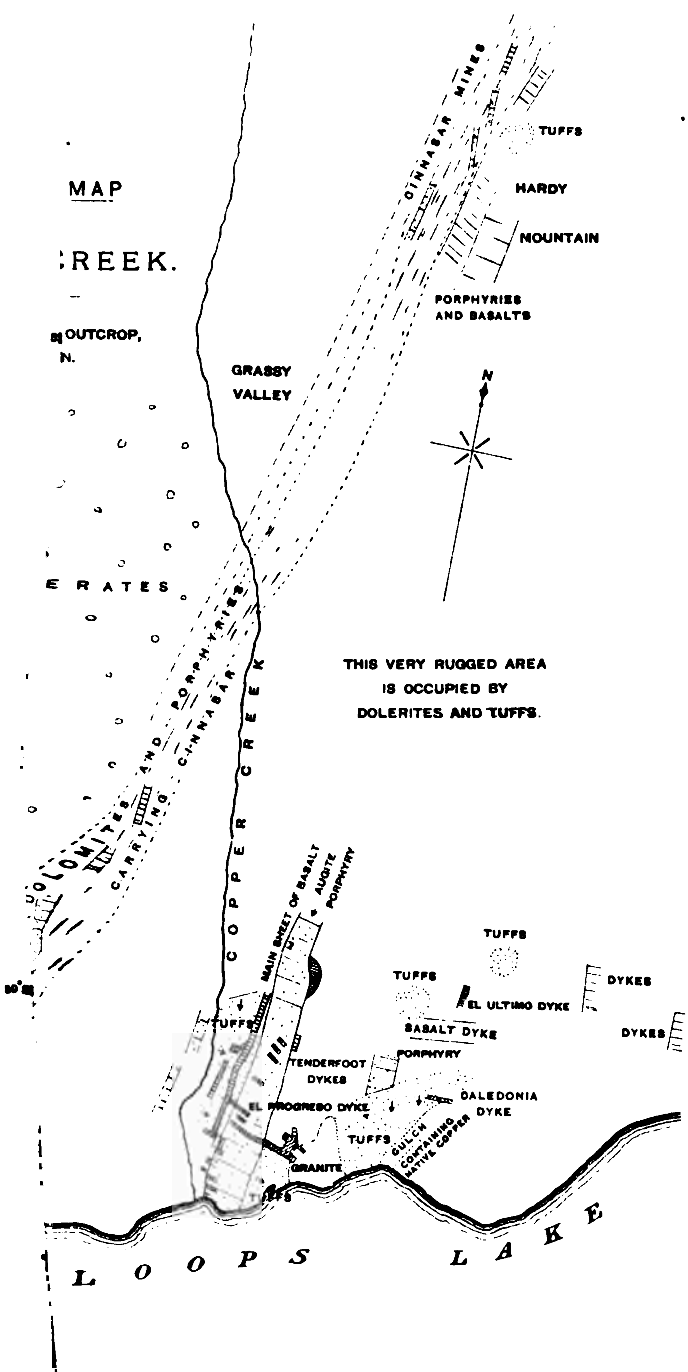
Mr. JOHN BATEY moved that a vote of thanks be given to Mr. H. C. Peake for his services in the chair.

Mr. A. SOPWITH seconded the resolution, which was unanimously adopted.

The following notes record some of the features of interest seen by the visitors to collieries and works, etc., which were, by kind permission of the owners, open for inspection during the course of the Sheffield Meeting on September 19th, 20th and 21st, 1899 :—

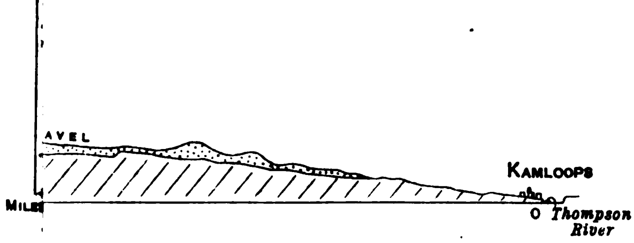


Scale. 4 Miles to 1 Inch.

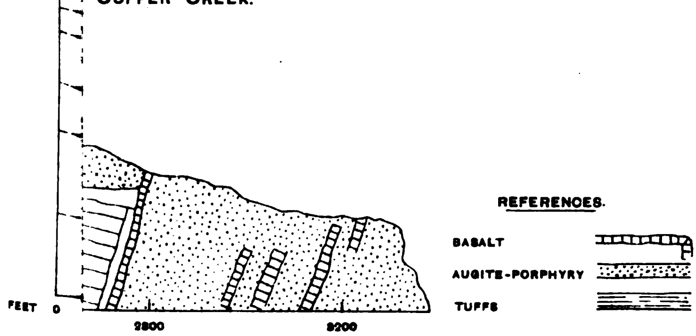


Scale, 2640 Feet or ½ Mile to 1 Inch.

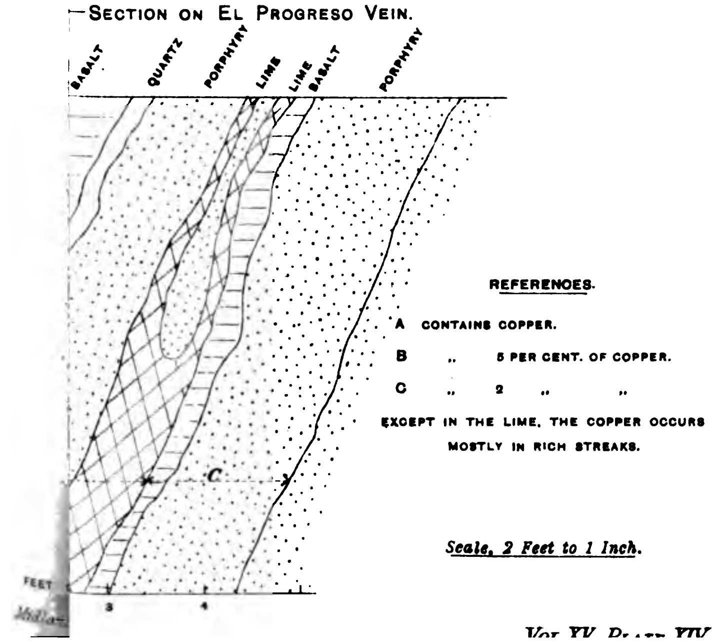
...tion shewing Position of the Tranquille Beds, South of Kamloops.



...ection immediately East of Copper Creek.



...—Section on El Progreso Vein.



References.

A contains copper.

B " 5 per cent. of copper.

C " 2 " "

Except in the lime, the copper occurs mostly in rich streaks.

Scale, 2 Feet to 1 Inch.

CADEBY MAIN COLLIERY.

Cadeby colliery is situate about 4½ miles west of Doncaster, and is at present the easternmost and deepest colliery in the Yorkshire coal-field.

Two shafts, each 16 feet in diameter and 264 feet apart, were sunk in 1889-1892, close to and on the deep side of the North Don fault, which has here a throw of about 400 feet. The sinking of the first 270 feet was through Boulder Clay, followed by fissured sandstone. Immense volumes of water were met with in sinking to this depth, and two years elapsed from the commencement of operations before the ingress of water was stopped, by lining the shafts with tubbing to a depth of 405 feet.*

The Barnsley coal-seam was reached at a depth of 2,250 feet, the section being:—

	Feet.	Inches.
COAL, soft (Day-beds)	1	1
Bags dirt	0	6
COAL, soft (Bags)	1	3
COAL, soft (Tops)	1	11
COAL, hard	3	4
COAL, soft (Bottoms)	2	0
Total	10	1

The system of working is longwall, each bank being 120 feet in length.

The haulage mainly consists of endless-ropes, to which the corves are attached by chains. There are also two self-acting inclines, about 2,100 feet long. At present, the haulage is being driven by a horizontal engine, having 2 cylinders each 24 inches in diameter by 4 feet stroke, the steam being conveyed down the upcast shaft. Arrangements are being made to replace the steam-engine by electric motors.

The winding-engine at the downcast shaft has a pair of cylinders, 45 inches in diameter by 6 feet stroke, fitted with Daglish trip-gear, steam-reverser and Daglish disconnector to the trip-gear, in order to give the engineman full control of the engine at any part of the journey. The drum is partly scroll and partly parallel, the scroll portion commencing with a diameter of 18 feet, the larger diameter being 33 feet, and the

* *Trans. Inst. M.E.*, vol. iii., page 513.

drum then becomes parallel. The winding ropes are of plough-steel, $5\frac{3}{4}$ inches in circumference. The cages have 4 decks, 2 tubs carrying 10 cwts. each being placed on each deck, and the cages are loaded and unloaded by hydraulic machinery, designed by Mr. W. H. Chambers.

The head-stocks are of latticed steel, which along with nearly all the other surface plant was built on the works.

The whole of the heapstead is built of steel, and is as yet incomplete and only partially fitted with screening arrangements. Two self-acting tipplers are erected, discharging upon two Chambers screens, which are at present dealing with about 1,800 tons per day.

The whole of the small coal is conveyed to a Humboldt washing-machine with a capacity of 100 tons per hour.

Ventilation is produced by a Schiele fan, 21 feet in diameter, driven by an horizontal engine with a cylinder 40 inches in diameter by 4 feet stroke. Provision has been made for duplicating both engine and fan, when necessary.

There are 16 Lancashire boilers, 30 feet long by $7\frac{1}{2}$ feet in diameter, fitted with Meldrum furnaces.

The workshops are built in one block and consist of a large fitting and erecting shop, provided with a 20 tons travelling crane, lathes, and machines for drilling, punching, screwing, planing, etc. The adjoining blacksmith's shop has 8 hearths, a steam-hammer, etc. There is also a large carpenter's shop for general work, a small shop for pattern-making, and a corf making and repairing shop fitted with 2 blacksmiths' hearths, screwing-machine, etc. There are also stores and sawmills. Above the stores are placed workshops for the plumbers and sadlers, laboratory, etc.

The Luhrig washer has a capacity of 50 tons per hour, it is connected with the pit-bank by a gantry on which tubs are conveyed by an endless-chain. This washer cleans the small coal required by the coke-ovens.

There are 180 Chambers improved bee-hive coke-ovens, externally heated by an arrangement of flues underneath them, producing good foundry coke. There are also in course of erection a number of Chambers coke-ovens, 30 feet long by 6 feet wide.

The whole of the plant has been laid out to deal with an output of 5,000 tons per day, when the colliery is fully developed.

EAST HECLA WORKS: MESSRS. HADFIELD'S STEEL FOUNDRY COMPANY, LIMITED.

The original Hecla Works are now as large as the available ground at Attercliffe will admit, and land has been acquired at Tinsley (closely adjacent to the Great Central Railway) to the extent of about 50 acres, on which has already been erected the machining, annealing, grinding, smithy and other shops. The new foundry was in course of construction, but from what could be seen of the work in progress everything appeared to indicate an extensive area; and when completed it will be one of the largest and most completely equipped foundries in this country.

The main foundry building is 600 feet long and 134 feet wide, and there are two supplementary foundries, 120 feet by 126 feet and 370 feet by 60 feet. The area covered is 131,500 square feet, with a sky-light area of 54,000 square feet. About 3,000 tons of steel has been used in the erection of the foundry. No cast-iron or woodwork has been used in the construction, and all columns are built, either of box section or braced, according to the load. The shops will be fitted with a large number of overhead and jib electric cranes, and will be lighted by incandescent lamps.

There is a complete equipment of drying-stores and shops for the treatment and storage of refractory materials used in steel-foundries and furnaces.

Adjoining the foundry are the boilers and engine-houses for the electric-plant. There will be 11 Lancashire boilers, and 6 are installed at present. The electric-power plant will comprise 5 engines and dynamos, 3 of which are now being erected of over 1,000 horsepower. The surface-condensing plant is capable of dealing with 2,000 horse-power, and is supplied with circulating-water from the river Don, through a culvert 600 feet long. There are also 4 Lancashire boilers, working steam-hammers, etc., adjoining the machine-shops.

The members witnessed the various processes through which the steel castings have to pass before they are ready for being despatched to the consumer. Castings for collieries seemed to predominate, such as tub-wheels, haulage-rollers, pulleys, etc. The work has been systematically specialized, so that several thousand tub-wheels are made per week,

and in the new department, specially devoted to the manufacture of tubs or corves, they are able to turn out several hundreds per week.

A model tramway (which had been specially erected) showed, in actual work, an improved tub-greaser, a tub controller, the W. & S. clip, Hadfield self-lubricating rollers and pulleys, as well as Rowbotham self-oiling wheels and axles.

The superiority of the Sylvester prop-withdrawer was demonstrated, an appliance with which props can be withdrawn with less risk to life and limb than is possible with the appliances ordinarily in use.

The members also saw, in various stages of manufacture, cylinders for hydraulic-presses, wheel-centres, horn-blocks for locomotives, buckets and pins for dredgers, castings for dynamos, and various types of armour-piercing projectiles, as well as common and shrapnel shell of different calibres.

There was a large display of castings and forgings made of Hadfield manganese steel, which has attained wide celebrity and extensive application for the great resistance it offers to abrasive action. It is specially suited for all conditions of severe service, and where ordinary steel wheels have not given satisfaction they have been abandoned in favour of manganese steel. The material is so hard that it cannot be machined, and is largely used for the jaw-faces and wearing-parts of crushing machinery, for the links and pins of elevators and conveyors, for colliery screens and many other purposes.

THE TINSLEY STEEL, IRON AND WIRE-ROPE WORKS: MESSRS. WILLIAM COOK & COMPANY, LIMITED.

The manufactures include wire-ropes, iron and steel bars, pig-iron, horse-shoes, channel-steels for indiarubber-tyres and wire-rods.

The members were shown the systematic methods of testing the individual wires in the wire-warehouse, before it was passed into the spinning-shops. The test-books showed that each end of every piece of wire was subjected to five tests, namely, one tensile, one torsion, one elongation and two bending tests.

In the spinning-factory the wire as received from the warehouse is wound upon bobbins and transferred as required to the stranding-

machines, where the first operation of spinning is done. The strands are automatically coiled on large bobbins, which (when full) are transferred to the finishing- or closing-machines, where the rope is laid and automatically wound into a coil. The coils, when tied up, are dipped into a large oil-tank.

An endless-hauling rope was being closed, oiled and wound upon a large drum fixed on a railway-wagon, which would be sent to the colliery, and with the help of a powerful brake, the rope could be lowered down the shaft and drawn through the workings by the old rope. This method saves time and labour, and was introduced at these works, where there are three reels with capacities of 25, 15 and 5 tons.

The rope-making machinery is driven by a high-pressure engine, with a pair of cylinders, 15 inches in diameter by 28 inches stroke, of the most modern type.

The wire-rod mill rolls steel-billets, 3 inches square down to a rod $\frac{3}{16}$ inch in diameter, in one operation, the rod being coiled by a steam-winch. This mill has an output of about 160 tons per week, and nearly the whole of the rods are used for wire-rope making.

The two blast-furnaces are supplied with iron-ore from the company's own mines at Frodingham, Lincolnshire. The pig-iron is subsequently mixed with hæmatite or Swedish pig-iron, puddled and rolled into finished bar-iron, the bulk of which is used for links, shackles, cages, drawbars, spring-hoops, etc. This department has an output of about 500 tons per week.

Four mills, each 20 inches, 14 inches, 10 inches and 9 inches in diameter, were seen rolling bar-iron.

A large number of channel-steels for indiarubber-tyres were shown for use on cabs, carriages, omnibuses and motor-cars.

Horse, pony and mule shoes are made by machinery from the iron produced in the works. They are made of every size in use and any pattern required, but standard patterns have been designed, and are kept in stock, ready for delivery.

Most of the boilers are heated by the waste-gases from the blast-furnaces, puddling-furnaces, and mill-furnaces.

The works are lighted by electricity, and a 10 tons electric crane is in use in the rope-factory.

Three locomotives, 150 railway-wagons and 30 horses and wagons convey the company's goods.

THE ATLAS STEEL-WORKS: MESSRS. JOHN BROWN & COMPANY, LIMITED.

The members visited the armour-plate rolling-mill, and saw the rolling of a thick plate for one of H.M. warships; together with the processes of annealing, tempering, and chilling the plates.

In the forging department, the hydraulic forging-press of 4,000 tons power is used for marine shafting, etc.; and the 10,000 tons hydraulic press for pressing armour-plates.

The marine-shafting and machine shops, and marine-furnace shop were also visited.

PRELIMINARY STUDY OF RECENT BORINGS MADE IN THE NORTH OF FRANCE IN SEARCH OF THE COAL-BASIN.*

By Prof. J. GOSSELET.

The borings which have been made during the last ten years in the North of France, with the view of striking the westerly prolongation of the great Franco-Belgian coal-basin are the outcome, not of mere empiricism, but of well-considered scientific hypotheses.

They may be classified in four groups, as follows:—(1) Borings of the Liane; (2) borings in Flanders; (3) borings in the Calaisis; and (4) borings in the Coastal belt.

(1) *The Liane Borings.*—The Liane borings were undertaken at the writer's suggestion, based on suppositions which have proved to be mistaken. Although he had long ago shown that the coal-basin of Hardinghen and Ferques is the continuation of the great Franco-Belgian field, he was not convinced that it was the sole representative of that coal-field. It appeared to the writer, indeed, that the Carboniferous Limestone and the Devonian sandstones which crop out south-east of Ferques and Hardinghen constitute an anticlinal fold, pitching southward beneath another coal-basin, the structure being similar to that observed near Namur.

This hypothetical coal-basin should lie between the sandstone-and-limestone anticline and the Great Fault, the position of which in this area was at that time quite unknown. Hence arose the idea of looking for the coal-basin somewhere in the south of the Boulonnais.

The foregoing assumptions received apparent confirmation from the results of a boring for water carried out at Desvres. A core from this boring had been shown to the writer, recalling vividly the Lower Coal-measures discovered some few years previously at Liévin and Drocourt, south of the coal-basin.

A preliminary boring (No. 31), put down at Menneville, north of Desvres, struck, at a depth of 486 feet, hard black compact shales,

* *Annales de la Société Géologique du Nord*, 1898, vol. xxvii., page 139; translated by Mr. L. L. Belinfante, M.Sc.

which also brought to mind the Lower Coal-measures. A second boring (No. 32), put down at Bournonville, went through exactly identical shales between the depths of 594 and 1,253 feet, as did a third boring (No. 35), at Wirwignes, between 755 and 1,667 feet. The scene of operations was then transferred more to the northward (No. 33 boring), near Le Waast, where the same shales were struck at 144 feet from the surface, but at 512 feet the red sandstones of the Upper Devonian came in.

Thus all this eastern portion of the Boulonnais is made up of shaly rocks which were referred to the Lower Coal-measures because they were in nowise analogous to any of the known Devonian rocks. There remained an alternative suggestion: might not these shaly measures be the Culm of British geologists, and would not the coal-basin then lie between this Culm and the Great Fault? At that time, the position of the Condros Ridge had not yet been determined: this ridge is characterized by the occurrence of Lower Devonian strata, Gedinnian or Coblentzian.

Another and a final trial (No. 34) was made at Cantraine, west of Samer. Here below the Jurassic, at a depth of 492 feet, red and green shales of undoubted Gedinnian age were struck. Here, then, we had abutted against the Condros Ridge.

Then the idea occurred to the writer that the shales which he had thought were Lower Coal-measures might after all be Silurian. Dr. Barrois examined them under the microscope, and failed to discover in them the carbonaceous granules characteristic of Coal-measure shales.

To sum up, the researches made in the Liane district lead to the conclusion that beneath the eastern end of the Boulonnais lies a Silurian massif analogous to the Silurian massif of the Condros, south of Namur and Huy. The further inference may be drawn that the Ferques and Hardinghen basin is the sole prolongation of the Pas de Calais coal-field.

(2) *Borings in Flanders.*—While the Liane borings were being carried out a splendid coal-field was discovered at Dover.* After a few years of hesitation several companies set to work in France, with the view of reaching there the continuation of the Dover coal-basin. Their search was guided by suppositions to which the writer did not subscribe: he held that the great Brabant plateau of Silurian shales and

* *Trans. Inst. M.E.*, Mr. W. Topley, vol. i., page 376; Mr. Marcel Bertrand, vol. v., page 106; Prof. W. Boyd Dawkins, vol. vii., page 533; and Messrs. F. Brady, G. P. Simpson and N. R. Griffith, vol. xi., page 540.

quartzites extends southward through Flanders up to the very edge of the Boulonnais. Still, he did not regard the discovery of coal in Flanders as absolutely out of the question, but he did think that, if so very problematical a coal-basin existed at all, it had no connexion whatever with the Franco-Belgian coal-field. Perhaps he may be allowed to quote what he wrote on this subject in 1891.*

North of the Devonian belt of which he had just spoken lies the great plateau of Brabant, made up of Cambrian and Silurian rocks. These strata have been identified from borings at Brussels, Ostend and Caffiers (between Marquise and Calais). It seems probable that this massif extends below the whole of the northern portion of the Nord, at a depth which had not yet been determined. There is no impossibility that coal-basins lie on its surface, comparable to those of Shropshire, which also lie upon Silurian measures. All one can say is that none such have been found as yet, unless we reckon among them the coal-field struck at Dover. It is possible that the Dover Coal-measures lie in a little basin on the surface of the same Silurian shales as those that have been struck in the Ostend and Caffiers borings. In that event, the series of coal-basins might well extend to the eastward as far as Calais. He had no fundamental objections to make to such an hypothesis: nevertheless, he did not agree with it.

Eleven borings were put down in Flanders in the department of the Nord, and in the neighbouring portion of the department of the Pas du Calais. Four alone struck Palæozoic rocks; and in view of the negative results yielded by these, the other borings were abandoned.

The four borings just mentioned were those of Noordpeenne, Le Guindal, Bray-Dunes and Gravelines (Nos. 27, 21, 26 and 20). They struck the Silurian either in the form of very hard compact black shales or in that of a white rock, the decomposition-product of these shales. So far, then, the writer's views were confirmed by the ascertained facts.

From these Flanders borings we learnt that the slope of the Palæozoic surface between Noordpeenne and Le Guindal is very steep. Thus at Noordpeenne the Palæozoic lies at a depth of 873 feet, while at Le Guindal and Gravelines it lies 262 feet or so deeper down (1,135 feet). But this surface rises again rapidly eastward, for at Bray-Dunes (on the Franco-Belgian frontier east of Dunkerque) the Palæozoic is reached at 951 feet and at Ostend at 1,017 feet.

(3)—*Borings in the Calaisis.*—In view of the unsuccessful result of the borings in Flanders, recourse was had to the hypothesis which the writer had put forward in 1891:—

* "Les Richesses Minérales de la Région du Nord" (The Mineral Wealth of the Nord District), *Annales de la Société Industrielle du Nord de la France*, 1891, pages 15 and 16.

He believed that the Dover coal belongs to the great Franco-Belgian basin, of which we find the prolongation in the Boulonnais. This great belt of Coal-measures, striking north-east and south-west from Dortmund to Namur, turns thence westward to Valenciennes, and on reaching Anzin strikes north-westward. Finally it is seen at Bristol and Swansea with an east-and-west strike. There seems a possibility that between Marquise and Dover the Coal-measures are shifted northward, either by a transverse fault or by a fold analogous to that which, near Douai, shifts them northward, and which for a long time misled observers as to their true direction. The important point is to find out the exact *locus* of this hypothetical fault. If it be in the Straits of Dover, then we need not expect to get coal at Calais. But the fault may be on French territory: once across the Boulogne and Calais road, the Palæozoic belt of the Boulonnais pitches abruptly beneath the Jurassic rocks, and it is likely enough that the northward shift takes place precisely on this spot.

The neighbourhood of Calais can hardly be regarded as a geologically unknown district. In boring for an artesian well (No. 36) in that town, a limestone was met with at a depth of 1,050 feet, which Elie de Beaumont identified as Carboniferous Limestone. At Guines (No. 37), at a depth of 735 feet, grey and red grits and shales were struck, which were pronounced to be Devonian. Such was the state of knowledge regarding the Palæozoic of the Calaisis when the new borings were started.

The first (No. 29) was put down at Coquelles, near Calais, and confirmed the discovery of Elie de Beaumont, for the same limestone was met with at 1,116 feet, and 282 feet lower down red fossiliferous Devonian shales were struck (1,398 feet). The limestone was again reached in the Sangatte boring (No. 15), west of Calais, at a depth of 456 feet, while what appeared to be Silurian shales were struck at 509 feet. It was a curious anomaly to find this limestone superposed upon the Silurian. Nevertheless the undoubted occurrence of Carboniferous Limestone at Calais was an argument which told much in favour of the writer's views: to find the Coal-measures the line of search should be directed westward.

Without entering upon a chronological account of the search, it will suffice to say that two borings (Nos. 9 and 10) were put down at Escalles, and that they struck the Silurian at the respective depths of 764and 771 feet. Whence we may infer that the limestone of Calais, Coquelles, and Sangatte is an isolated outlier upon the Silurian. About 1½ miles south-east of Escalles is the Folle-Emprise boring (No. 11), which struck the red Devonian measures at 814 feet; two miles further on we come to the Anglaise boring (No. 12), which also met with the red Devonian, at a depth of 689 feet. Following the coast ever west-

ward to Strouanne (No. 8), unmistakable Coal-measures were found at 545 feet, with three coal-seams in normal positions, and having well characterized roof and floor. At a depth of 968 feet, the boring passed out of Coal-measures into limestone.* The coal met with in this boring was similar in character to the Hardinghen coal. Here, then, we had found the link between the Dover basin and that of the Boulonnais.

We were entitled to hope that these Coal-measures would be continued southward, but unfortunately the facts did not bear out these hopes. Borings put down at Hervelinghen (No. 6) on the south-east, at Le Colombier (No. 5) on the south, and at Tardinghen (No. 3) on the south-west, struck in the first case the Devonian, and in the latter two the limestone. From this it might have been inferred that the Wissant coal-basin was of very small extent; nevertheless the search was continued. Two other borings were put down at Wissant, the southernmost (No. 4) of which struck what were probably Devonian shales at 705 feet, while in the northernmost (No. 7) undoubted Carboniferous Limestone was met with at 623 feet.

If we add to the foregoing results that at Witerthun, the bore (No. 30) has touched Carboniferous Limestone, we may safely conclude that the Devonian and Carboniferous basin of the Boulonnais, the undoubted prolongation of the Namur basin, is shifted northward west of the Boulogne and Calais road, a throw which the writer had sketched and foretold with tolerable correctness in 1891. By this disturbance, the various measures have been in all likelihood as greatly fractured as they are in the vicinity of Hardinghen, and it would be more than rash to attempt to work them for coal.

(4) *Borings in the Coastal Belt.*—There was still another geological problem awaiting solution. It is well understood that the Lower Boulonnais is essentially a dome of Jurassic rocks jutting up amid the great Cretaceous plain of the Nord. All the borings in the Calaisis were put down through the Chalk to the north-east of the Jurassic outcrops. Those of the Liane had been put down near the southern boundary of the Lower Boulonnais. What was the condition of things below the Jurassic dome? No man could tell.

It seemed possible that between Wissant and Samer extended a Devonian and Carboniferous tract, crumpled and fractured like that of

* In this limestone was a little band of red shale, which has induced some to determine it as Devonian.

Ferques, within which there was some hope of hitting upon coal. Now, it was natural to assume that if this hypothetical coal-basin did exist it corresponded tectonically to one of the Jurassic synclines. Wherefore a boring (No. 2) was put down in the Wimereux syncline at the Pas de Gay, north of Aubenge: here the Silurian was met with at a depth of 1,453 feet. Another boring (No. 1), put down at Framzelle, near Cape Gris-Nez, on the Gris-Nez anticline, struck the same rocks at a depth of 1,486 feet.

We now know, then, that the dome of the Boulonnais corresponds in its western, as it does in its eastern, portion to a Silurian plateau, and all hope of finding coal therein appears vain. Yet at Framzelle, the Silurian rocks are unconformably overlain by red measures, the age of which is in dispute.* Without prejudging the information which may be gained from a study of the Jurassic rocks bored through, it is already evident that the geotectonic anticline of the Boulonnais Jurassic overlies a deep depression of the Palæozoic surface. This surface indeed lies almost exactly at the same level, 425 to 460 feet below ground, at Strouanne, on the north of the Boulonnais, and at Samer, on the south. Between these two extreme points stretches a broad depression corresponding to the Jurassic dome of the Boulonnais :—

	Feet.
Strouanne	− 453
Tardinghen	− 604
Framzelle	− 1,306
Pas de Gay	− 1,263
Wirwignes	− 689
Samer	− 440

What is the age of this Palæozoic depression? How has a lower orographic syncline changed into an upper geotectonic anticline? These questions will be answered, it is hoped, by a study of the Jurassic rocks traversed in the above-mentioned borings.

Conclusions.—If we return to purely stratigraphical considerations we notice that the Silurian massif of the Boulonnais occupies a position analogous to that of the Silurian massif of the Condros, between the Gedinnian, south of Samer, and the Great Fault, proved at Le Waast, which passes between Framzelle and Tardinghen. It differs from the Condros massif by its much greater width: as to its exact age no positive assertion can be hazarded, for the only fossils that have been found are

* The Framzelle boring (No. 1) struck, at a depth of 1,168 feet (altitude −988 feet), red rocks, which the writer considers to be Triassic, but which others take for Devonian.

undeterminable fragments of graptolites. The existence of this massif could hardly have been suspected, as the Silurian belt of the Condros is betrayed by no outcrop to the east of Charleroy, neither had it been traced into French territory nor into England south of the Bristol coal-field.

The discoveries recorded in the Boulonnais are not alone in demonstrating the important part played by the Silurian Series in the constitution of the deep-lying portion of the Condros Ridge in the Pas de Calais district. In the course of recent exploration-work, the mining engineers of the Liévin collieries have struck, south of the concession, black calcareous shales, in which Dr. Barrois has recognized characteristic Upper Silurian fossils.

This outlying patch of the Condros Ridge is cut off from the workable coal-seams by a fault of very low hade. We may suppose that the Silurian of Liévin is the forerunner of the massif which spreads out in the Lower Boulonnais, and very probably extends across the Channel beneath the Weald.

The Silurian rocks, which have been found below the Boulonnais, appear, to the writer, to be the primary origin of the dome of the Boulonnais. It is the remnant of a primary anticlinal fold, anterior to the Devonian epoch, since the Devonian rests unconformably upon the Silurian. It is probable that this Silurian fold extends also beneath the Weald.

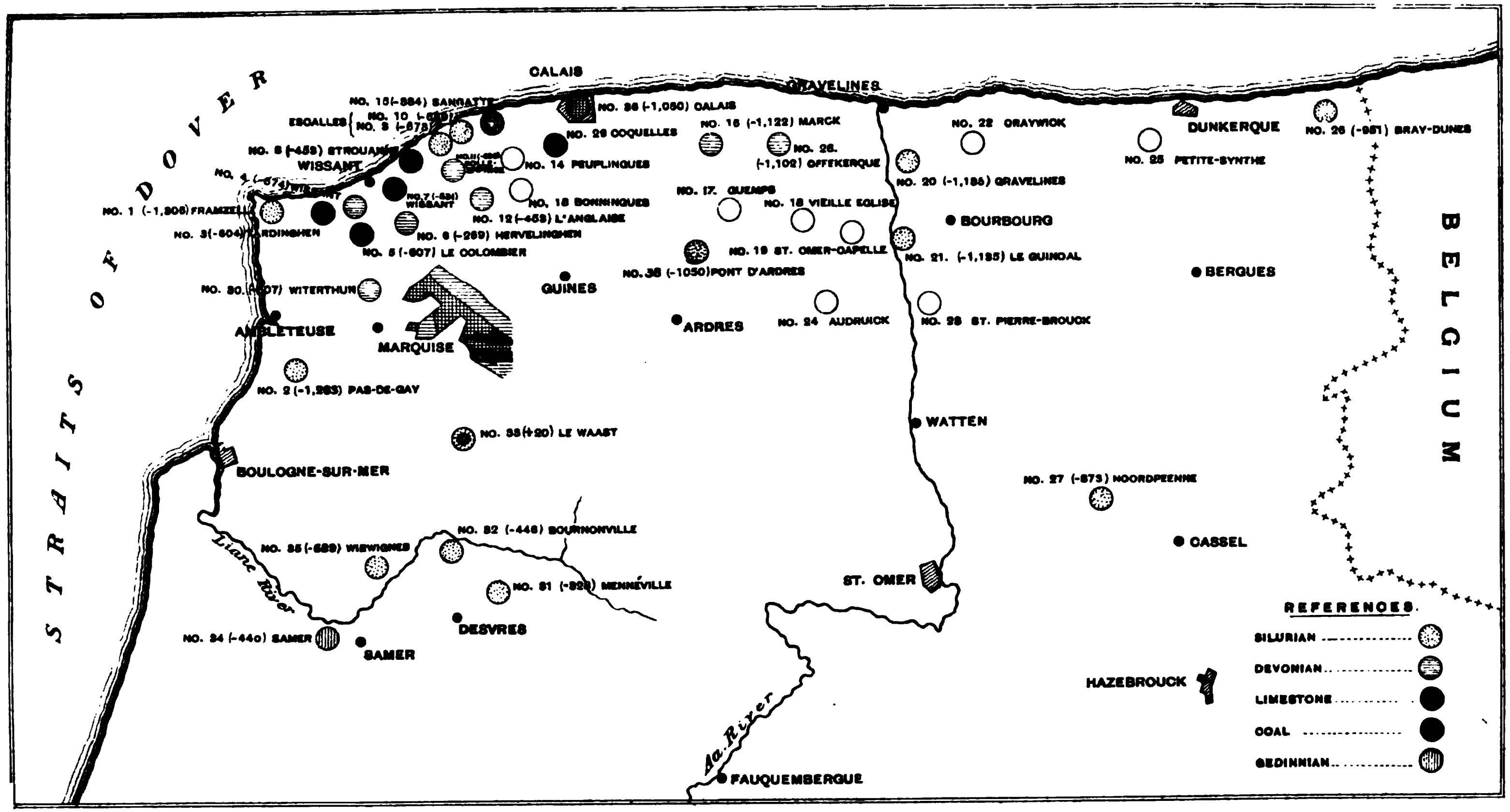
We see, then, how complex are the problems which mineral industry calls upon geology to expound. If geologists are happy in being able sometimes to offer useful guidance to those who seek and win minerals, on the other hand, they willingly admit that borings and workings supply them with invaluable data for the correction of mistakes and the progress of science. More than £20,000 has been expended upon these borings with no satisfaction to those who have undertaken them beyond the consciousness that they have tried their utmost to enrich France with a new coal-field.

In conclusion, the writer thanks Mr. Dinoir, mining engineer at Lens, who has kindly communicated almost all the information upon which he had based this paper, and Mr. L. Breton, who has supplemented that information in so far as regards the borings which he directed.

APPENDIX.—Table of Borings (Plate XIV.).

Nos.	Locality of Boring.	Depth of the Palæozoic Surface.	Height of Locality Above Sea-level.	Altitude (Depth Below Sea-level) of the Palæozoic Surface.	Depth of the Boring.
		Feet.	Feet.	Feet.	Feet.
1	Framzelle	Silurian ... 1,486	180	− 1,306	1,493
2	Pas de Gay	Do. ... 1,453	190	− 1,263	1,503
3	Tardinghen	Limestone ... 702	98	− 604	787
4	Wissant, South ...	Devonian ... 705	131	− 574	925
5	Le Colombier ...	Limestone ... 738	131	− 607	869
6	Hervelinghen ...	Devonian ... 577	308	− 269	925
7	Wissant, North ...	Limestone ... 623	92	− 531	630
8	Strouanne	Coal-measures 545 Limestone .. 968	92	− 453	978
9	Escalles	Silurian ... 771	98	− 673	797
10	Escalles	Do. ... 764	95	− 669	824
11	Folle-Emprise ...	Devonian ... 814	164	− 650	846
12	L'Anglaise	Do. ... 689	236	− 453	696
13	Bonningues	—	—	—	—
14	Peuplingues	—	—	—	—
15	Sangatte	Limestone ... 456 Silurian ... 509	72	− 384	554
16	Marck	Devonian ... 1,148	26	− 1,122	1,230
17	Guemps	—	—	—	—
18	Vieille-Église ...	—	—	—	—
19	St. Omer-Capelle ...	—	—	—	—
20	Gravelines	Silurian ... 1,148	13	− 1,135	1,444
21	Le Guindal	Do. ... 1,148	13	− 1,135	1,198
22	Craywick	—	—	—	—
23	St. Pierre-Brouck ...	—	—	—	—
24	Audruick	—	—	—	—
25	Petite Synthe ...	—	—	—	1,066
26	Bray-Dunes	Silurian ... 961	10	− 951	1,453
27	Noordpeenne ...	Do. ... 965	92	− 873	1,027
28	Offekerque	Devonian ... 1,122	20	− 1,102	1,188
29	Coquelles (Calais) ...	Limestone .. 1,116 Devonian ... 1,398	—	—	1,230
30	Witerthun	Do. ... 656	49	− 607	1,975
31	Menneville	Silurian ... 486	158	− 328	791
32	Bournonville ...	Do. ... 594	148	− 446	1,253
33	Le Waast	Do. ... 144 Devonian ... 512	164	+ 20	532
34	Samer	Gedinnian ... 492	52	− 440	551
35	Wirwignes	Silurian ... 755	66	− 689	1,667
36	Calais, artesian well	Limestone ... 1,050	0	− 1,050	—
37	Guines	Devonian ... 735	—	—	—
38	Pont d'Ardres ...	Silurian (?) ... 1,083	33	− 1,050	—

To illustrate Prof. J. Gosselet's "Preliminary Study of Recent Borings made in the North of France" etc.



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THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE CHRISTIAN INSTITUTE, GLASGOW, FEBRUARY 7TH, 1900.

MR. JAMES T. FORGIE, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen were elected :—

ASSOCIATE MEMBERS—

Mr. WILLIAM E. P. BOWIE, 90, Dobbie's Loan, Glasgow.
Mr. ALEXANDER FREW, 90, Dobbie's Loan, Glasgow.

Office-bearers for the session 1900-1 were nominated.

DISCUSSION OF MR. THOMAS H. MOTTRAM'S PAPER ON "EXPLOSIONS OF FIRE-DAMP AND COAL-DUST IN THE WEST OF SCOTLAND."*

Mr. T. H. MOTTRAM referring to a paragraph in his paper respecting the use of safety-lamps,† said that since the last meeting he had gone through the list of accidents that had occurred at seven collieries, which for the last eight years had more or less used safety-lamps; and he had also gone back for a further period of eight years, during which time these pits were working with open lights. He ascertained that between 1883 and 1890, at these collieries (where 1,223 persons had been employed underground) there had been 10 fatal and 47 non-fatal accidents. During the latter period, when safety-lamps were in use, namely, from 1891 to 1898 (and when the average number of persons employed underground at these collieries had

* *Trans. Inst. M.E.*, 1899, vol. xviii., page 186.

† "Arguments have been adduced against the use of safety-lamps to the effect that a more general application of their use might probably reduce explosions; but that, on the other hand, accidents by falls of roof, etc., would increase, the miner having been deprived of the superior illumination afforded by the open light."—*Trans. Inst. M.E.*, 1899, vol. xviii., page 192.

increased from 1,223 to 1,626), there had been 11 fatal and 40 non-fatal accidents, by which 42 persons were injured. Thus there had been a total of 53 accidents during the period when safety-lamps were in use, compared with 57 during the open-light period. He was not prepared to state that this improvement had been effected chiefly by the introduction of safety-lamps, but he thought the figures showed that in the West of Scotland, at all events, the use of safety-lamps was not accompanied with an increase in the number of accidents from falls of sides and roof.

Mr. J. B. Atkinson (H.M. Inspector of Mines, Glasgow) remarked that Scotland, with regard to the number of explosions of fire-damp, did not compare favourably with England and Wales. It was a bad feature of these accidents in Scotland that so many happened in the hands of subordinate officials, namely, firemen and roadsmen. Generally speaking, he (Mr. Atkinson) believed that, if the General and Special Rules were rigidly observed by officials as well as workmen, there would be fewer accidents. Firemen should make scrupulous use of safety-lamps instead of naked lights when examining workings in mines where gas was found. He suggested that some check should be instituted over the firemen to ascertain that they attended to this all important detail. Recently, a fireman had been killed in the Slamannan district by making an inspection with a naked light, although he had a safety-lamp, in a section of the pit where gas had been found. Frequently, when accidents happened to firemen in that way, they had a story that the safety-lamp went out and that they struck a match to light it; and one could not very easily disprove that statement. In his mines-inspection district (East of Scotland), many explosions happened in oilshale-mines; and during 1899, out of 36 explosions, 16 occurred in oilshale-mines.

Mr. R. W. Dron (Glasgow), with reference to Mr. Mottram's remarks* that the firemen should be impressed with the necessity of reporting every accumulation of gas, said it was a well-known fact that the average fireman in a non-fiery mine had great repugnance in reporting gas, and no doubt many small accumulations were not reported. While surveying a non-fiery colliery recently, he saw gas ignited in three different ventilating-districts, and although in one case the fireman got his hair singed, the report books showed "all clear." Was it necessary that a fireman should

* *Trans. Inst. M.E.*, vol. xviii., page 190.

report every "capful" of gas found at a brushing-face or in a hole in the roof? Many firemen had an impression, rightly or wrongly, that a literal interpretation of the Coal-mines regulation Act would be resented by the employers. Probably, pressure on the part of H.M. inspectors of mines might clear away this erroneous impression. The fireman should have more power to compel the miners to erect such screens or hurdle-screens as he considered necessary. Mr. Mottram seemed to advocate the abolition of open lights in so-called non-fiery mines; but the following quotation from the annual report for 1890, of Mr. J. T. Robson, H.M. inspector of mines for South Wales, was significant:—"Discarding explosions, and including all other underground fatal accidents and loss of life, it appears that naked-light collieries were 25 per cent. and 28 per cent. safer respectively, calculated on the persons employed, and 34 per cent. and 37 per cent. safer respectively on the quantity of minerals raised." In view of such figures. the drastic remedy of abolishing open lights altogether was not likely to lead to good results. Reform should rather be sought by increasing the stringency of the regulations regarding the examinations and reports made by the firemen, and giving to the firemen such an official standing as would make them less anxious to conceal discoveries of gas. It might be a step in the right direction if the mid-day inspection were made by a man who was not in any way responsible for the maintenance of the bratticing or screens, and had thus no interest in concealing any accumulation of gas due to defective screens, etc.

The PRESIDENT (Mr. J. T. Forgie) said that Mr. Mottram's paper had opened his eyes as to the position occupied by Scotland with regard to accidents from fire-damp and coal-dust. He had always had the idea that coal-mines in England (particularly in some districts of that country) were more dangerous in regard to explosions and miscellaneous accidents than the coal-mines of Scotland. Mr. Mottram (by the figures he had adduced) had brought clearly before the members the necessity for precautionary measures being adopted to reduct the explosions in connexion with which only one or two persons were injured. These small accidents totalled up to a figure much greater than a large and more serious explosion. The General Rules of the Coal-mines Regulation Act and the Special Rules seemed to be ample, and he did not think that the introduction of any further rules would be of great advantage. No ordinary workman (no matter

how satisfactory his elementary education might be) could possibly read these rules and afterwards retain them in his memory. He (Mr. Forgie) advocated that the General Rules and Special Rules should be considerably reduced in number, and made less complex and verbose, so that an ordinary workman might be able to grasp their meaning more readily. Of course, each official had his own particular duties to perform, and only required therefore to attend particularly to a certain portion of the rules; but the ordinary collier, the ordinary fireman, and the ordinary roadsman were not too well acquainted with two-thirds of the General and Special Rules. The majority of small accidents were due to slight unforeseen circumstances; others were attributable to a slight negligence, and were pardonable; while others, again, were caused by sheer negligence, and were unpardonable. It was difficult to ascertain the proportion of accidents due to each of these three causes, but he thought that if they found the officials generally were doing their best to enforce the General and Special Rules, they should not blame them too much for slight mistakes. Where there was the slightest danger of an explosion happening in any colliery, or where gas had been found to accumulate to a dangerous extent within any reasonable time, he thought that the colliery-owner, without the least hesitation, should adopt the use of safety-lamps. At one time he was so strenuous in his opposition to the introduction of safety-lamps that he went into a serious arbitration with one of H.M. inspectors of mines, and the arbiter gave his decision in favour of the introduction of safety-lamps into some of the pits. He must admit that after several years' experience of working with safety-lamps in these pits, he had completely changed his opinion. Previously, he had frequent cases of small burnings and fires in the pits, but since the introduction of safety-lamps he had pleasure in saying that there were almost none. The underground fires—which were sometimes most expensive and dangerous—had entirely disappeared, and he believed that there had not been a single life lost since the innovation. He would go the length of saying that safety-lamps should be introduced into mines which were considered as fiery; and in this connexion the question arose as to the definition of a fiery mine. Was a mine fiery where gas had been found within a certain period, or should a mine be considered as non-fiery in which gas had not been found within the previous 12 months?

Mr. Mottram had referred to the loss of life and injury to person

sustained by falls of roof in mines conducted with safety-lamps, and sometime ago he (Mr. Forgie) had also made reference to this particular matter. At that time, he stated that injuries from falls of roof had not decreased in the same ratio as other accidents, owing, in great measure, to the introduction of safety-lamps ; and he still adhered to that statement. The anticipated reduction of loss of life and injury to person by falls of roof and side had not taken place in recent years, and he attributed the want of improvement—to a great extent—to the introduction of safety-lamps. If the members referred to the reports of H.M. inspectors of mines for the last 10 or 20 years, they found that there had not been the same improvement or reduction in the percentage of loss of life and injury to person by falls of roof and side as in the other classes of accidents. No man could deny the fact that the safety-lamp afforded a poorer light than the naked lamp ; and the workmen who wrought with a light which was worse than another, to which he had got accustomed, was bound not to be able to do the work of supporting and propping so satisfactorily, and at the same time to see the dangers and flaws in his working-place, as clearly and distinctly. He anticipated that in the near future a better safety-lamp would be invented. He had no doubt that at the present moment engineers all over the world were engaged in perfecting or bringing out a safety lamp which would give a superior light, and one almost equal to the naked light.

Regarding Mr. Dron's suggestion that the general manager or the the manager should appoint a neutral inspector to make a mid-day inspection, he considered that a morning inspection by the fireman was quite sufficient, especially if the fireman carried out the General Rules to the very letter, that no man was to be allowed into his working-place if there was the least sign of danger in it. The question of the interference of a neutral person as inspector was always offensive to the management, and he questioned whether Mr. Dron's suggestion would be beneficial.

Mr. J. B. Atkinson, with reference to Mr. Dron's remarks as to firemen reporting small quantities of gas, said that firemen were bound to report the occurrence of any gas. It was certainly necessary to keep a record, and if H.M. inspector of mines found all the cases notified in the book had been prudently dealt with, that was all he could expect. Mr. Dron made further remarks with regard to the erection of screens, but this was a matter which miners did not undertake and was part of the duty of firemen and roadsmen. Mr. Forgie had attempted to show that there had been no great or substantial

improvement from falls in the case which Mr. Mottram had cited, where safety-lamps replaced naked lights. He was of opinion, from the figures Mr. Mottram had brought forward, that there had been a great improvement, because the number of workmen employed at the seven collieries alluded to had increased from 1,223 to 1,626, while the number of accidents had at the same time decreased. He did not argue that the introduction of safety-lamps had decreased the accidents from falls, but that their introduction had evidently led to no increase of that class of accident.

Mr. MOTTRAM pointed out that Mr. Atkinson was perfectly correct in his impression. He showed, taking the increased number of workmen into account, that about 20 accidents had been averted. Of course he was not prepared to urge, as he had already explained, that this improvement was wholly the result of the introduction of safety-lamps, and yet it was a significant fact that such an improvement had shown itself in a way to which no other part of the West of Scotland could lay claim.

The PRESIDENT (Mr. J. T. Forgie) explained that some time ago he had adduced statistics* to show that during the past ten or fifteen years, when there had been an increased use of safety-lamps (the light from which was admittedly inferior), the number of accidents from falls of roof and side had not decreased rapidly. He thought it was a natural deduction that a man was unable to do as efficient work in comparative darkness as if he were working with a clear and distinct light.

Mr. D. M. MOWAT (Coatbridge) said that Mr. Mottram made some remarks on the use of mixed lights.† While he agreed with Mr. Mottram that it was not good practice to have a safety-lamp at the face and a naked light at the road-head, he thought that the General Rule, which insisted that whenever a safety-lamp was used in a working-place, no naked light was to be used between that working-place and the return air-course, was not a good one; as in cutting a fault or other work of that nature, safety-lamps would many a time be used without hesitation, but for the fact that this would entail the putting of safety-lamps into the remainder of the district between that point and the return-airway.

The discussion was adjourned.

* *Trans. Inst. M.E.*, vol. xv., page 122. † *Ibid.*, vol. xviii., page 191.

DISCUSSION OF MR. ROBT. W. DRON'S PAPER ON "THE PROBABLE DURATION OF THE SCOTTISH COAL-FIELDS."*

Mr. R. W. DRON stated that the following corrections should be made in the figures contained in Table I.:—Kilwinning, Upper Coal-measures, for "26 square miles" read "24 square miles."† Falkirk, Carboniferous Limestone, coal-seams lying below the Upper Coal-measures, for "41,190,000 tons" read "47,190,000 tons."‡ Slamannan, Carboniferous Limestone, coal-seams lying below the Upper Coal-measures, for "47,190,000 tons" read "102,510,000 tons;" this correction adds 61,320,000 tons to "Reserve Coal."§ On page 207, line 19, for "1,540,000,000 tons" read "1,504,000,000 tons." The apparent discrepancies in the figures relating to the Carboniferous Limestone-measures in Edinburghshire were due to an allowance made for the dip of the strata. The title of the last column of Table V. should read "Consumption" instead of "Output."‖ Regarding the output of Lanarkshire, although the proven coal would last for about 40 years, it was wellknown that the upper seams of the Clydesdale basin (which had been so extensively wrought during the last 20 years) would become practically exhausted in the course of the next 10 or 12 years.**

Mr. JAMES S. DIXON (Glasgow) wrote that the members and others interested in the subject of the coal-supply of the country were deeply indebted to Mr. Dron for the great amount of painstaking research which he had undertaken in estimating the quantities of coal remaining unworked in the different coal-fields of Scotland. In making such an estimate, a considerable amount of latitude must be observed, and after taking every care the quantities could only be approximate. Without giving to the details the same amount study as that which Mr. Dron had done, it was not possible to check his conclusions in regard to quantities.

In 1884, with the object of giving evidence in Parliament, on a Railway Bill, he made a careful estimate of the quantities in the upper seams down to the Virgin coal-seam in the Clyde Basin to 3 miles above

* *Trans. Inst. M.E.*, 1899, vol. xviii., page 194. † *Ibid.*, page 195.
‡ *Ibid.*, page 196. § *Ibid.*, page 196.
‖ *Ibid.*, page 209. ** *Ibid.*, page 211.

Hamilton, and for an average width of $4\frac{1}{2}$ miles. This estimate was made from colliery-plans in all cases where these were available, and the quantity was 395,000,000 tons. At that time, the estimated output (from these seams) of the collieries within the same area was 5 to 6 millions of tons a year, and this had since then been largely increased. In the 16 years that have since elapsed, it was probable that more than 100,000,000 tons had been exhausted. Probably the balance was now being worked at the rate of 10 to 12 millions of tons a year, and that might even be increased for a few years longer, but from the nature of things it would then begin to decrease and be continued in smaller quantities for many years. In the immediate neighbourhood of Hamilton, the prospect of workable seams being found under the Splint coal-seam was very discouraging. Several bore-holes had been put down to the depth of the Lower Drumgray coal-seam, and no coal found exceeding 2 feet in thickness. These seams, however, were found, and were now being worked to the east and north. The lower series of measures were brought to the surface to the south of Hamilton by the Eddlewood slip, but the thick coal-seams of the Fife, Lothian and Douglas coal-fields in that position seemed to be entirely wanting. This being so, the immediate neighbourhood of Hamilton would cease to be a productive coal-field long before some of the districts where coal had been worked far longer, and which were at present comparatively in the background. He noticed that Mr. Dron, in treating of the Ayrshire coal-field, had omitted the district about Mauchline, because the quantities that might be found at a workable depth were very uncertain. That area was troubled with intrusive volcanic rocks and slips, but there were great possibilities in the large unproved district around Mauchline and Tarbolton, and if coal existed in a workable state the depth would constitute no bar to its being wrought. There were also immense possibilities in the Canonbie and Annan districts, which in future years might become leading coal-producing centres. He also thought that Mr. Dron's estimate of the coal in the Lothians was far too moderate. He had not gone into it in detail, but he had always considered that this coal-field contained by far the largest quantity of any in Scotland.

Mr. James Hamilton (Glasgow) said that Mr. Dron had gone into this very important and difficult investigation with great industry. It was a very difficult matter for any one to approach this subject directly, because it was practically impossible for an individual to collect the information necessary to determine how much coal remained to work in

the coal-fields of the country. That would be possible only to a Government Commission with unlimited powers of demanding information. Mr. Dron had adopted the safer method of calculating the total quantity of coal in Scotland and deducting what had been worked. The data for ascertaining the quantity of coal that had been worked was very unreliable, because in the early workings of coal the proportion lost must have been exceedingly high—a large proportion having been left in pillars, and in the workings in the shape of dross. In the past history of mining in Scotland, returns, if made from output, were certainly much less than the actual output. Mr. Dron had made a reduction of nearly 40 per cent. to cover all deficiencies, but it was certain that coal ought to be worked with considerably less than 40 per cent. of loss, even allowing for faults and other uncertainties. He (Mr. Hamilton) had endeavoured to check Mr. Dron's figures in a rough way, in so far as they related to Lanarkshire. Calculation in a matter of this kind must be the roughest approximation, because no one had the information necessary, nor the details requisite, to make an accurate estimate for the whole coal-field. From his calculation, he thought that there was a reasonable probability of the quantity of coal estimated by Mr. Dron for Lanarkshire being ultimately found workable. Looking to the result of Mr. Dron's calculations of the quantity of coal still available in Lanarkshire, there was a total of 885,000,000 of "reserve coal"; but he (Mr. Hamilton) might point out that a large proportion lies in the Carboniferous Limestone underneath the Upper Coal-measures in the Clyde basin, at a depth greater than any at which coal is being worked in this country. All the available information about these rocks is got from the fringe round the Coal-measures where they come to the surface. Along the south-western boundary of the Clyde basin, the Carboniferous Limestone-measures are thrown up against the Coal-measures, and the full thickness is not seen, apparently a considerable thickness of the upper beds being denuded away. A 2 feet seam of coal is known to exist at several points along this south-western margin, while, as pointed out by Mr. Dron, seams of much greater total thickness are found on the east and north. It would appear, therefore, that Mr. Dron's estimate of 2 feet of coal in the Carboniferous Limestone in the Clyde basin is not unreasonable. With the progressive advance in mining engineering and the increasing scarcity of coal, depth, thickness, and even quality are likely to be factors of diminishing importance in determining whether a coal-seam is workable, and this has to be set against the evident uncertainty attached to Mr Dron's estimate of "reserve coal."

Mr. J. B. ATKINSON (H.M. Inspector of Mines, Glasgow) said that Mr. Dron's paper touched upon a very important subject, and it was one, moreover, about which there was great room for difference of opinion. Mr. Dron spoke as if seams less than 2 feet thick were not workable, but he (Mr. Atkinson) knew that many such seams were worked in the east of Scotland. Further, Mr. Dron said that "below the Virgin coal-seam there are two groups of lower seams, (1) the Virtuewell, Kiltongue and Drumgray seams, and (2) the Shotts seams." * The seams which had been most wrought in the Shotts district were the Upper and Lower Drumgray coal-seams, but he supposed that what Mr. Dron alluded to as the Shotts seams where those known as the Armadale seams. Although these latter seams were being opened up in the Shotts district, they could scarcely be called Shotts seams.

The following paper, by Mr. Wm. D. L. Hardie, on "Endless-rope Haulage at Lethbridge Colliery," was read :—

* *Trans. Inst. M.E.*, vol. xviii., page 199.

ENDLESS-ROPE HAULAGE AT LETHBRIDGE COLLIERY.

BY WM. D. L. HARDIE.

It is very essential that some means of conveying the coal from the miners to the pit-bottom in a steady and uniform manner be established. This requirement became very apparent at the Lethbridge colliery before the roads were much extended, altogether apart from the cost of hauling. The management gave considerable thought to all the systems of hauling, and finally decided that only endless-rope, working under the cars, could be utilized with any great degree of success, as the roads were somewhat tortuous, the grades irregular, and the passage-ways narrow and closely timbered. And as there were many stations where empty cars must be taken off the rope and loaded cars put on, the making of turn-outs for main-and-tail-rope haulage would have been very costly, and even when made there was no assurance that they could be maintained.

The grades and narrow gauge, not to mention the other objections, precluded the use of electric motors, and the high-speed motor presented one of the many objections to main-and-tail-rope haulage. The passage-ways are all closely timbered, and, if the cars left the track at high speed, they would rip out the timber and cause large and dangerous falls of roof, which would destroy the output until the damage was repaired.

The question of cost was one that the writer had hoped to go into fully, but so many disturbing elements have been encountered that a comparative cost-statement at this time is out of the question. However, the writer is safe in stating that when the endless-rope haulage is utilized to its full capacity of 1,000 tons of lump coal in 8 hours, a saving of at least 2d. (4 cents) per ton hauled will be effected.

The company had on hand, not in use, a hoisting-engine, with 2 cylinders 18 inches in diameter and 36 inches stroke. The hoisting-drum was removed, and gearing and endless-rope driving-drums were substituted as shown in Figs. 2 and 3 (Plate XV.). The following extract from the specifications gives the number of wheels, etc., used :—

2 driving-drums, 6 feet in diameter, with 5 grooves, wood-lined, each turned for rope, 1 inch in diameter, bored and brass-bushed for shaft, 10 inches in diameter, and fitted with clutch-ring, 5 feet in diameter, with Lane band-friction clutch and operating levers, keyed to shaft. 1 shaft, 11 feet long and 10 inches

in diameter. 2 Babbitt-lined pillar-block bearings, 18 inches wide, for shaft, 10 inches in diameter. 1 spur-wheel, 24 inches in diameter, to be bored out, fitted and keyed on shaft, 10 inches in diameter. 1 pinion-wheel, 8 feet in diameter, bored and key-seated for the shaft, 10 inches in diameter. 20 sheaves, 3 feet in diameter, grooved for rope, 1 inch in diameter, with shaft, 4 inches in diameter and 18 inches long: these sheaves must work loose on the shafts. 40 bearings, 6 inches wide, for shaft, 4 inches in diameter. 4 wood-lined sheaves, 6 feet in diameter, grooved for rope, 1 inch in diameter, to work loose on shaft, 6 inches in diameter. 2 shafts, 6 inches in diameter and 8 feet long, for sheaves, 6 feet in diameter. 6 bearings, 8 inches wide, for shaft, 6 inches in diameter. 4 wood-lined sheave-wheels, 5 feet in diameter, grooved for rope, 1 inch in diameter, bored for shaft, 6 inches in diameter: the sheaves must work loose on the shaft. 1 shaft, 6 inches in diameter and 6 feet long. 2 bearings, 8 inches long, for shaft, 6 inches in diameter. 8 tightening or friction-sheaves, 5 feet in diameter, wood-lined grooved for rope, 1 inch in diameter, loose on shaft and bored for shaft, 6 inches in diameter. 2 shafts 6 inches in diameter and 4 feet long. 4 bearings, 8 inches wide, for shaft, 6 inches in diameter. 300 chilled-iron guide-sheaves, with spindles, plates, etc. (Fig. 5, Plate XV.). 1,000 maple-wood rollers, 6 inches in diameter and 15 inches long, fitted with iron bands on end, and spindles running clear through and extending 3 inches on each end. 2,000 wooden brackets for roller-bearings, 3 inches by 4 inches by 24 inches. 2 collars, 3 inches by 3 inches, for shaft, 10 inches in diameter. 1 Evans governor, to control engine within 5 per cent. 24,000 feet of best crucible steel rope, Lang lay, 1 inch in diameter. 8 miles of signalling wire, with all necessary fittings. 10 electric bells. 2 boilers, each of 100 horsepower.

The drawing (Fig. 1, Plate XV.) shows that there are two separate haulage-systems, one on each side of the pit, and about 10,000 feet of rope are used in each haulage.

The speed of the ropes varies from 1½ to 2 miles per hour. If there was an abundance of mine-cars, the speed of 1½ miles per hour would give the smoothest running rope. The pit was not originally laid out with a view to any hauling-arrangement other than by horses, with the result that in order to guide the rope nearly in the centre of the roads about 400 iron and wooden guide-sheaves, including sheaves used at curves, are required. The carrying-rollers are placed 25 feet apart, so that the rope in no part of its length touches the floor of the mine.

A double road in one entry is an impossibility, owing to the roof, and as shown by Fig. 1 (Plate XV.), the rope is led inbye in one entry and outbye in the other.

On the south side, a gripper-man in the pit-bottom couples two empty cars together, then attaches them to the rope by a screw-grip (Fig. 10, Plate XVI.), which hauls the empty cars to an empty-

car transfer, where a boy takes off one car, or both, as the cars may be required at the different stations.

There is a gripper-man at each of the stations, who takes off the empty cars as they are required and puts on the loaded cars as they come to the rope. The loaded cars put on the rope beyond the transfer go clear round with the rope, and are detached by another gripper-man at the pit-bottom.

On the north side, the same procedure is followed, excepting that both loaded and empty cars are transferred at the points marked "loaded-car transfer" and "empty-car transfer" (Fig. 1, Plate XV.).

On both sides, no regular number of loaded cars are attached to a grip. A person may pass from 1 to 8 cars on a grip in travelling along the road. However, there are sections where the road is so steep, both with and against the load, where it is better not to put more than 2 cars on a grip at these particular places. Only 1 grip is used, and that on the front end of a trip, be it a 1 car or an 8 cars trip.

Figs. 11 to 16 (Plate XVI.) show the grades on the various roads and are self-explanatory.

Fig. 6 (Plate XV.) shows an end view of the mine-car (5 feet long, 3 feet wide and 1¾ feet deep, inside measurements) used at Lethbridge colliery. This car, loaded as shown in Fig. 6, carries about 1,800 pounds of lump coal, but the average load in a day's run is 1,600 pounds. When pillars and stumps are being drawn the roads heave, so that in many instances the cars can only be loaded level-full. On this car, a draw-bar is used with a coupling-chain and hole at one end, and a hook and hole at the other end. This makes it possible to haul cars singly or in trips from either end on the rope, and in the secondary haulage by horses.

Figs. 5 and 6 (Plate XV.) also show the iron guide-sheaves used.

Figs. 8 and 9 (Plate XV.) show the arrangement for conveying the endless-ropes round curves shown at A and B, Fig. 1 (Plate XV.). They also show the switch-arrangement for passing cars on to or off the rope.

Figs. 17 and 18 (Plate XVI.) show the construction of the sheave-wheels, excepting that the hub is wider in all the wheels used where there is plenty of room.

Figs. 2 and 3 (Plate XV.) are a plan and a section of the surface-arrangements. As shown by the plan (Fig. 3), the loaded rope runs into the first groove of the driving-drum, thence back over the first tightening-wheel, then back to the second groove in the driving-drum,

thence back to and over the second wheel in the tightening-car, and so on until five half-turns are placed on the driving-wheel and four half-turns on the tightening-wheels. The rope leaves the last groove of the driving-drum and passes down the shaft, but between the driving-drum and the shaft there is a small tightening-wheel to take up the slack rope from the shaft. It was found on starting the rope, that there was always a certain amount of slack rope at the pit-bottom which took up when the rope was fairly started. In one case there was enough slack rope to put a very bad kink in the rope, which led to the insertion of the small tightening-wheel.

Fig. 4 (Plate XV.) shows the arrangement of wheels, etc., at the pit-bottom.

It will be seen from Fig. 3 (Plate XV.) that each rope is worked by the Lane friction-clutch, and that either driving-drum can be worked quite independently of the other, and one or both can be stopped or started without stopping the engine.

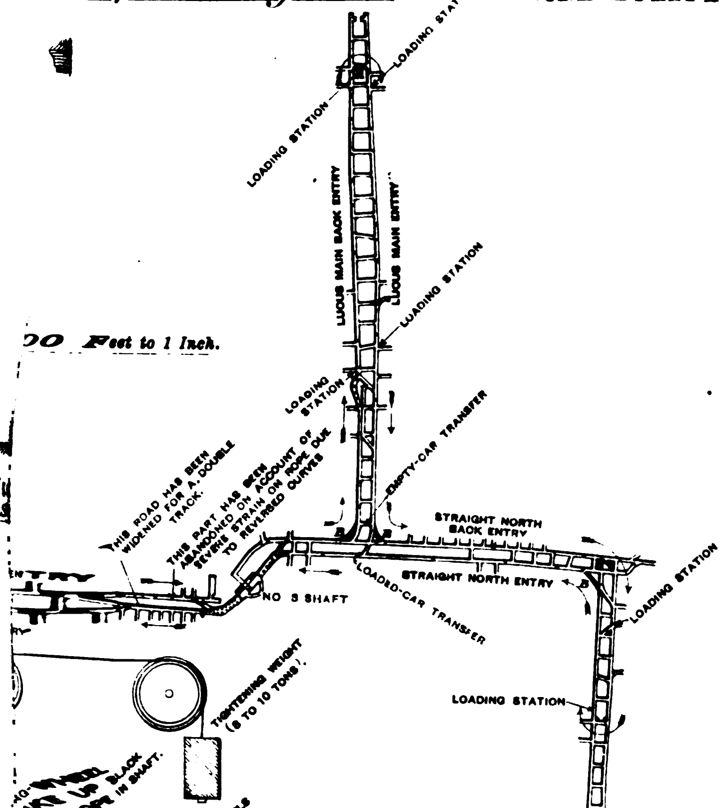
A spring rope-tightener is shown on one rope, and a weight-tightener on the other, but actually there is a spring and weight rope-tightener on both.

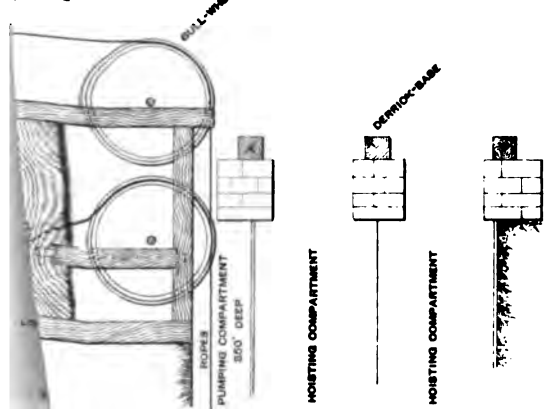
There are several excellent friction-clutches in use in the United States of America, but in the writer's estimation there is no clutch so simple and so efficient as the Lane friction-clutch. Fig. 7 (Plate XV.) shows the Lane friction-clutch attached to a small engine, and gives a very clear view of the clutch. The driving-disc, *A*, is keyed on to the shaft, and the drum is loose on the shaft. When the lever, *B*, is pulled back, the clutch-rod, *C*, revolves, and moves up the sliding-sleeve, *D*, which in turn moves the arm-link, *E*, so that the movable-arm, *F*, tightens the strap, *G*, on the clutch-ring cast on the drum. *H* is a fixed arm bolted on to the driving-disc, *A*. By the screw and nuts, *N*, any grip can be given to this clutch. This clutch will take grip enough for a load to stop the engine, or it can be set so that the least bit of an overload will cause the clutch to slip.

The endless-ropes on the north and south sides, at present, are working very smoothly, each hauling about 400 tons of lump-coal in 8 hours, at a speed of 1½ miles per hour. If there were plenty of men at work, the ropes would just as smoothly convey 500 tons as 400 tons each.

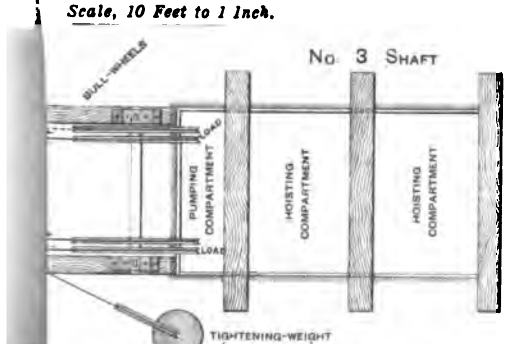
Rails 26 feet long and weighing 9⅓ pounds per foot are used on all the hauling-roads.

Three signalling wires are used, following the same course as the





Scale, 10 Feet to 1 Inch.



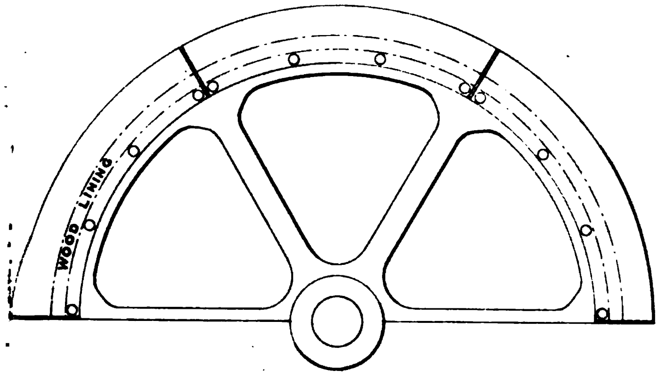
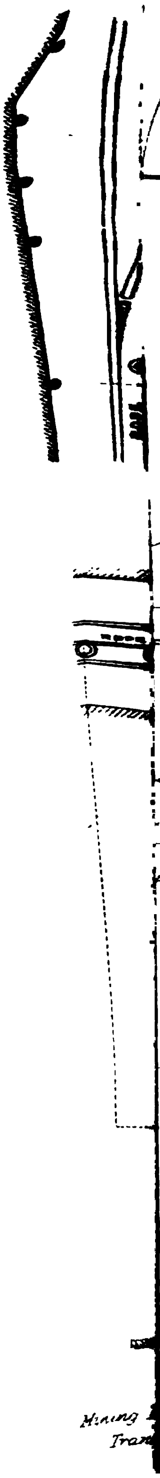
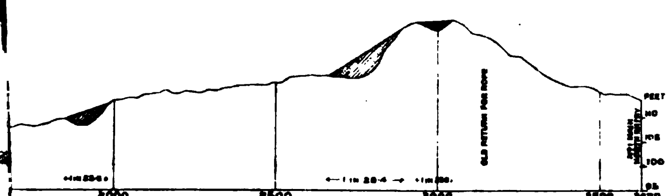


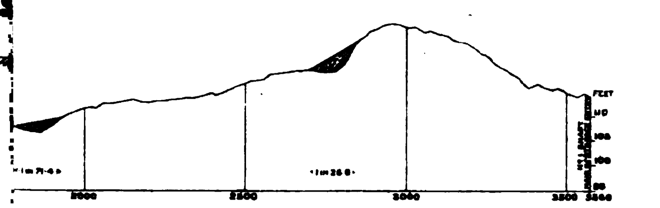
FIG. 18.—PLAN.

Scale, 2 Feet to 1 Inch.



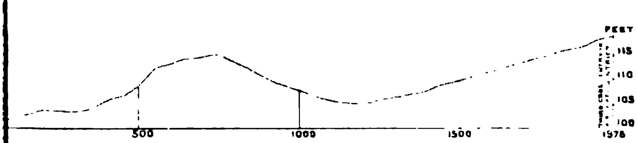


MAIN SOUTH ENTRY.



[M]AIN SOUTH BACK ENTRY.

15.—STRAIGHT NORTH ENTRY FROM PIT-BOTTOM TO SECOND CROSS ENTRY IN AIR SHAFT DISTRICT.



16.—STRAIGHT NORTH BACK ENTRY FROM LUCAS MAIN ENTRY TO THIRD CROSS ENTRY IN AIR SHAFT DISTRICT.

[V]ertical Scale, 40 Feet to 1 Inch.

rope—two naked wires for signalling from below at any point to the engineer on the surface, and an insulated wire for the engineer to reply. There are 7 electric-bell stations on each side in the pit, which repeat the engineer's signals. A system of pocket-telephones is in use, which the writer hopes to explain in a paper at some future date.

The rope is made of best patent crucible-steel (Lang lay), of 67,200 pounds' breaking strain. It consists of 6 wire strands twisted on a hempen centre; each strand is composed of 9 wires about $\frac{5}{64}$ inch in diameter, twisted on a centre composed of 7 wires about $\frac{3}{64}$ inch in diameter, making a rope 1 inch in diameter. The splices are 100 feet long.

In conclusion, the writer gave the taper drum much consideration, but concluded that, with the present inside arrangement, it was not the most suitable. However, the drums have been made so that in the future, when there will be no further extensions, and no intermediate loading stations, the wooden lining can be taken out, the tightening-wheels taken off and a taper section substituted on the driving-drum.

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING

HELD IN THE MASON UNIVERSITY COLLEGE, BIRMINGHAM, MARCH 26TH, 1900.

MR. JAMES LINDOP, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting and Council Meetings were read and confirmed.

The following gentlemen were elected :—

MEMBER—

Mr. C. H. McCALL, Mining Engineer, Assam, India.

STUDENT—

Mr. HORACE D. POOLE, Mine Surveyor, Stourbridge.

DONATION TO THE BIRMINGHAM UNIVERSITY.

The SECRETARY (Mr. Alexander Smith) directed the attention of the members to the resolution which the Council had adopted "that in view of the ultimate benefit to the district, and to mining interests particularly that will accrue from the scientific departments of the proposed Birmingham University a donation of 50 guineas towards the funds be made by this Institute."

DISCUSSION OF MR. A. SMITH'S PAPER ON "THE RATING OF COAL-MINES." *

The SECRETARY (Mr Alex. Smith) said that before any discussion took place he wished to point out to the members that his paper on "The Rating of Coal-mines," was read and printed in the *Transactions* prior to the publication of the paper by Mr. George Humphreys-Davies on the same subject with the accompanying discussion.† He found that almost the whole of the contributors to the discussion agreed with his view, that the royalty should be taken as a basis, and disagreed with the principle advocated by Mr. Humphreys-Davies.

* *Trans. Inst. M.E.*, vol. xviii., page 171.
† *Ibid.*, vol. xviii., page 228.

Mr. W. J. HAYWARD thought that if the members could do anything to promote legislation as to the mode of assessment it would be a very satisfactory matter.

The SECRETARY replied that there was a commission appointed by the House of Commons and they had recorded the whole of the evidence in a voluminous report. Nothing at present had been done, but when the Government had time he believed that they intended to bring in a comprehensive measure dealing with the whole of such matters.

Mr. A. SOPWITH said that Mr. Smith had put in a very concise form the aspects of colliery rating as viewed by the authorities: niceties, must however, be swept away. The various arguments which were used, and which, indeed, could be supported, pointed out that there was really nothing specific to rate, and as there could be no definite basis, they always had to return to the hypothetical tenant, pure and simple. however much we might seek to involve him in a network of detail. Details might be requisite to some extent, but general principles or views would as a rule govern any decision, and broad—though not arbitrary—bases should be established for different districts. There would always be some exceptional cases, as for instance the Denaby colliery case. In that case, and in the way he would put it, the decision might be viewed as the establishment of a basis, there being (at least he considered that was the assumption), no means of doing so on precedent. He did not, however, hold with the view that it was necessary to deal with the accounts, but the outcome was the opinion that a rent could only be arrived at in that way in such an exceptional case. Presumably, however, a rent or royalty fixed in a new district, or under new conditions, as in the case in question, would be a ruling factor in the assessment of new adjoining collieries. He did not see why royalty and tonnage-making rent should not form a basis when the establishment of a standard had taken place. There were two arguments against this—one was that individual royalties could not be taken, as there might be a difference of 50 or 100 per cent. between collieries leased in bad times and in good times, or between long intervals; and the other was that it did not follow that the rent in either case might be sufficiently high for the hypothetical tenant on account of specially good trade ruling. The answer to the first argument was that there was really no practical reason for assuming that an average royalty could not be fixed. If the lessee of a colliery was paying, say, one half the

royalty that another did, and under approximately similar conditions, there was room for adjusting an hypothetical basis as between the two, and so on with other collieries in the district ; in point of fact, the standard royalty of the district was the pivot on which most assessments turned, subject of course to material differences as to expense of working or difficulties. With respect to the standard not being sufficiently high for the hypothetical tenant at any period—the establishment of this contention would point to good trade, and it seemed unfair to assess the collieries to a greater extent than was measured by the increase of tonnage. In the case of, say, a single colliery in an union it would be manifestly unfair to increase the rent materially beyond the increased tonnage. The separate rating of plant and machinery appeared to be an unnecessary complication: and although there were many arguments why they should be separate items, common sense appeared to dictate that if one colliery required extra maintenance for a much larger establishment than another colliery turning out a similar output, an hypothetical tenant would naturally say that if he had to pay more rates for extra plant he must pay a reduced standard royalty as a set-off. The differences between collieries could be adjusted by variable statutory deductions applying to the whole rental. He quite agreed with Mr. Smith that there was now a sufficiently fair approximation as to the value of royalties, making the establishment of a standard for any district a practicable matter. A basis on this ground appeared to be much more within the meaning of the hypothetical tenant than assessing a colliery on its accounts, which practically meant profits. If there could be a consolidation of the opinions of the authorities on the subject, and the latter were all accepted, there would be some satisfaction in the fact that the Act of Queen Elizabeth would become null and void.

Mr. Thomas Bell (Scarborough) wrote that he had always held the opinion that a rate per ton on the output was the fairest way of dealing with the question. He had latterly valued all the Cleveland ironstone-mines on this principle. He took into consideration all the varying conditions of the mines, working costs, water, timbering, distances from the furnaces, quality of stone, in fact everything, making due allowance for capital, etc. He found what he considered would be a fair rent for a lessee to pay, then, for rating purposes, he fixed a price per ton of stone drawn to bank. Nearly every mine varied, and so far as he knew the system had worked satisfactorily.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE, FEBRUARY 10TH, 1900.

MR. WILLIAM ARMSTRONG, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meeting on January 27th and that day.

The following gentlemen were elected, having been previously nominated :—

MEMBERS—

Mr. IVO WILLIAM BALDWIN, Mining Engineer and Colliery Manager, Oakleigh, Ruardean, Gloucestershire.

Mr. CHRISTOPHER ERNEST BUCKLE, Engineer in charge of the Ajjampur Mine of the Kadur-Mysore Gold Mines, Limited, c/o Mr. T. T. Leonard, 4, Gordon Avenue, Bangalore, Mysore Province, South India.

Mr. JOHN HENRY BACON FORSTER, Mining Engineer, Cramlington Colliery, Northumberland.

Mr. GEORGE ALFRED GREENER, Mining Engineer, Netherton Hall Colliery, Newcastle-upon-Tyne.

Mr. GERALD HOPKINS, Metallurgical Chemist and Engineer, British Columbia Bullion Extracting Company, Silica, Rossland, British Columbia

Mr. ALBERT LITTLEJOHN, Colliery Manager, Killingworth Colliery, Newcastle, New South Wales.

Mr. WILLIAM HENRY MASCALL, Colliery Manager, Zetland House, Cockton Hill, Bishop Auckland.

Mr. FRANCIS JAMES OAKES, JUN., Mining Engineer, 58, Pearl Street, Boston, Massachusetts, United States of America.

Mr. CHARLES EDWARD PARISH, Mechanical Engineer, Ouston Villa, Chester-le-Street, County Durham.

Mr. FREDERICK CARDELL PENGILLY, Mine-manager, Mikado Gold Mining Company, Limited, Rat Portage, Ontario, Canada.

Mr. JAMES EDWARD RIDDLE, Colliery Manager, Shilbottle Colliery, Lesbury, R.S.O., Northumberland.

Mr. PHILIP RHINELANDER ROBERT, Mine-manager, Greenland, Ontonagon County, Michigan, United States of America.

Mr. JOHN ROBINSON, Colliery Manager, 2, River View, Blaydon-upon-Tyne.

Mr. Ernest Henry Thomas, Mining Engineer, Oakhill, Gadlys, Aberdare, South Wales.

Mr. Iltyd Edward Thomas, Mining Engineer and Mineral Estate Agent, Glanymor, Swansea.

Mr. John William Thompson, Mining Engineer, Greenfield House, Crook, R.S.O., County Durham.

Mr. Joseph Burr Tyrrell, Consulting Mining Engineer, Dawson, Yukon Territory, Canada.

Mr. Cuninghame Wilson-Moore, Mining Engineer, Steynsdorp, Transvaal.

Associate Member—

Mr. Anthony Wilson, Thornthwaite, Keswick, Cumberland.

Associates—

Mr. John George Heckels, Colliery Surveyor, Broomhill Colliery, Acklington, Northumberland.

Mr. George Mather, Colliery Under-manager, Double Row, New Delaval, Newsham, R.S.O., Northumberland.

Students—

Mr. Robert Clive, Assistant Viewer, St. Helen's Colliery, Bishop Auckland.

Mr. Christopher Heaps, Mining Student, 12, Richmond Terrace, Gateshead-upon-Tyne.

Mr. Tom Wilson Hunter, Assistant Surveyor, Peases West Colliery, Crook, R.S.O., County Durham.

Mr. Edwin Walter Milburn, Mining Student, Link View, Blyth, Northumberland.

DISCUSSION OF MR. HARRISON F. BULMAN'S PAPER ON "THE KALGOORLIE GOLD-MINES, WESTERN AUSTRALIA,"* AND MR. S. J. BECHER'S PAPER ON "THE KALGOORLIE GOLD-FIELD."†

Mr. Frank Owen (London) wrote that the occurrence of telluride-ores in Colorado was by no means confined to Cripple Creek (El Paso county)—though that of course was by far the leading centre of production—but they were also found in other localities at a considerable distance, and in a somewhat different formation. Boulder county had produced telluride-ores for nearly the last 30 years, and long before the Cripple Creek region was known to contain them. According to the Colorado Bureau of Mines,‡ the mines of Boulder county produced in 1898, gold to the value of £119,856 ($581,302·41), the bulk of which came from high-grade telluride and sulphide-ores. The Commissioner of Mines in his report for 1897 stated that:—"Boulder county has long been noted for its production of varied telluride-ores, and has contributed many thousands of dollars in value to mineral collections. This fact can better

* *Trans. Inst. M.E.*, vol. xvii., page 349. † *Ibid.*, vol. xviii., page 42.

‡ *Bulletin*, 1899, No. 3.

be appreciated when it is stated that some of the ores produced have a gold value of $150 (£30 18s. 6d.) per pound, and from a mineralogical standpoint are priceless." In addition to the telluride-minerals referred to by Mr. Bulman, petzite and nagyagite are found in the Boulder county mines. According to Mr. J. H. Collins, the former contains: gold 18 to 25 per cent., silver 40 to 47 per cent. and tellurium 32 to 36 per cent., whilst the latter corresponds to the formula $2PbAu+3 TeSbS$.

He noticed that Mr. J. J. Sandeman criticized the West Australian mining laws unfavourably, as compared with those of the United States of America. He had had some experience of both, and would say that the American "law of the apex" (or the right to follow a vein indefinitely in depth on its dip) was generally deplored by mining-engineers in that country. This law stated that—

> The locators . . . . shall have the exclusive right of possession and enjoyment of all the surface included within the lines of their locations, and of all veins, lodes and ledges throughout their entire depth, the top or apex of which lies inside of such surface-lines extended downward vertically, although such veins, lodes or ledges may so far depart from a perpendicular in their course downward as to extend outside the vertical side-lines of such surface-locations. *

This one clause had given more money to American lawyers than any other in the statutes of the United States and on the Cripple Creek field there were few mines which had escaped prolonged and costly litigation at one period or other of their career. He believed that one of the leading mines (the Portland) in that camp had to fight no less than 36 lawsuits to confirm their title.

Mr. H. F. Bulman (Burnopfield) wrote that the experience gained at the Kalgoorlie gold-mines during the period that had elapsed since his paper was written showed that the treatment of sulphide-ores by crushing, roasting, and cyaniding was not so successful as was anticipated. What appeared to be a more satisfactory process had been discovered by Dr. Diehl, and a plant had been erected at the Hannans Brownhill mine in 1898. It was completed at the time of the writer's visit in October of that year, but secrecy was maintained about it, and visitors were not allowed to see it.

It was reported that the Lake View Consols mine had tried the Diehl process recently, and had decided to adopt it. At this mine during the past year there had been some trouble in connection with the Brown straight-line roasting furnaces.†

* U.S. Statutes, section 2,322. † *Trans. Inst. M.E.*, vol. xi., page 369.

It had been found, too, that finer crushing was required than had been anticipated. The Chilian mills had proved unsatisfactory for this purpose, and additional Krupp ball-mills had been erected. The ore was now crushed fine enough to pass through a 30 meshes in place of a 20 meshes screen.

Another difficulty arose in the cyanidation process. After 12 days in the vats, the roasted pulp tended to cement together. To remedy this inconvenience, the finer material was treated separately by agitating it with cyanide solution for 4 hours, and then putting it through filter-presses. This process yielded an average extraction of 95 per cent. The coarser material was treated in the leaching vats in the ordinary way.

It might be interesting to record what had been done at this, the leading mine of the district, during the year that had elapsed since his paper was written. During the year ended August 31st, 1899, 85,889 tons of ore had been raised, and 199,230·335 ounces of bullion had been extracted. This produce was equal to a yield of 2·319 ounces per ton, and taking the value of the bullion at £3 16s. per ounce, the value of the ore raised was £8 16s. 3d. per ton. The cost of working was £2 3s. per ton, which included 3s. 6d. for depreciation of plant and machinery. The total mining cost was 18s. a ton, and the cost of reducing the ore was 18s. 5d. a ton.

The great bulk of the output, namely, 81,866 tons, was oxidized ore, which had been put through the stamp-mill. Bullion weighing 56,506·475 ounces had been obtained by amalgamation, making a yield of 13·8 dwts. per ton, at an average cost of 6s. 10½d. per ton. The battery-tailings consisted of 44,323 tons of sands, 35,136 tons of slimes, and 90 tons of concentrates. Under the cyanide treatment, the sands yielded 10·6 dwts. per ton at a cost of 5s. 11d. per ton, and the slimes treated in the filter-presses yielded 6·6 dwts. at a cost of 7s. 6d. a ton. Sulphide-ores weighing 1,403 tons were treated at the mine, and yielded 3·19 ounces per ton at a cost of £3 16s. 9d.; and 2,620 tons of sulphide-ores, shipped to smelters in New South Wales, produced 38·976 ounces per ton at a cost of £7 4s. 5½d., including cost of shipping.

At increasing depths, the gold-bearing formation was maintaining its character, rich chutes alternating with barren or low-grade ground.

Prof. H. LOUIS (Durham College of Science), said that the "law of the apex" caused a great deal of trouble in districts where it operated. By this law, the person who worked the mineral at its outcrop was also entitled to follow the vein to any depth.

Mr. M. WALTON BROWN said that Mr. John Calvert had noted the occurrence in Australia (probably in Western Australia) of "tellurium, associated with lead, containing 110 ounces of gold to the ton."*

DISCUSSION OF MR. A. RATEAU'S "EXPERIMENTAL INVESTIGATIONS UPON THE THEORY OF THE PITOT TUBE AND THE WOLTMANN MILL."†

Prof. A. RATEAU wrote that he had read with great interest the remarks made upon his paper by Mr. Bryan Donkin, Prof. Henry Stroud, Mr. C. Chree and Mr. W. H. Dines at the meeting of August 5th, 1899. He was pleased to note that his own experiments and theories were, upon the whole, in agreement with the work which these gentlemen had done on the same subject, and was proud to receive such authoritative confirmation.

Messrs. Chree and Dines had shown that they had previously arrived at conclusions analogous to his own, and in some respects more general. He begged to thank these gentlemen for their kindly having sent him copies of their works, admitted readily their priority, and apologized for his ignorance of the work done by them, which he would otherwise have certainly quoted in his paper. In consequence of the large number of technical periodicals, it was difficult for anyone to keep himself informed of everything that was published in different countries, and it might be said that on many special questions like this one, the researches carried out in one country were almost entirely unknown in others. The investigations of Messrs. Chree and Dines more particularly applied to meteorology, whilst his own (Prof. Rateau's) had more direct reference to hydraulic and mining engineering. Though having been undertaken with such different objects, their results mutually supported each other.

Mr. Chree had directed his attention especially to the Robinson cup-anemometer, which was employed by meteorologists to the exclusion of the helicoidal anemometer (Woltmann mill). The latter was, on the other hand, the only one used for measuring air-currents in mines. The action of the air on these two classes of instruments was not the same. In the Robinson anemometer, the hemispherical cups present varying surfaces to the air-current throughout each revolution of the axis, whilst in the Woltmann mill the vanes always presented

* *The Gold-rocks of Great Britain, etc.*, London, 1853, page 235.

† *Trans. Inst. M.E.*, vol. xvii., page 124; and vol. xviii., page 16.

similar surfaces to the air-current, provided that the latter was parallel to the axis of the instrument. It would therefore not be surprising that the formulæ for these two classes of instrument should differ notably. Mr. Chree had taken for the equation of motion of the Robinson cup-anemometer :—

$$\frac{dv}{dt} = -a_0 - a_1 v - b_1 V - a_2 v^2 - 2b_2 v V + c_2 V^2 \quad . \quad . \quad . \ (1)$$

where V indicated the velocity of the wind, v that of the cups of the anemometer, and a_0, a_1, a_2, b_1, b_2, and c_2 were constants. In the second member of the equation, the general form of a function of v and V of the second degree would be recognized. This formula included, accordingly, as special cases, all formulæ in which v and V were in the second degree only. He (Prof. Rateau) thought that he had proved that for the Woltmann mill the co-efficients a_1 and a_2 of Mr. Chree were zero, which simplified the formula considerably and allowed of its integration in terms of v. Mr. Chree had pointed out that in studying the variable condition, Prof. Rateau had employed an equation which differed from that which he had established for a permanent condition. This was only an apparent contradiction, due probably to the fact that he (Prof. Rateau) had perhaps not explained matters in sufficient detail. In the permanent condition of motion, he had taken into account the friction of the spindle of the machine and of the air against the vanes, whilst in variable motion he had neglected this friction in order to simplify the formula. Accordingly, in equation (1) not only were a_1 and a_2 equal to zero, but also a_0 and b_1, whilst on the other hand, $2b_2$ was equal to c_2, so that the equation was reduced to :—

$$\frac{dv}{dt} = -c_2 v V + c_2 V^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \ (2)$$

And he had solved that equation. Mr. Chree's paper should be referred to* to see how the equation (1) might be solved, more particularly in some simple cases that were laid down.

At the end of his remarks, Mr. Chree pointed out with much reason that the term " hydrometer " was an objectionable one. This word was but little employed in France, and he had borrowed it from German authors.

Mr. Dines had studied extensively not only the anemometer, but also the Pitot tube, to which he had given a new shape for measurement of the velocity of the wind. In this form, the straight tube surrounded

* *The London, Edinburgh and Dublin Philosophical Magazine*, 1895, vol. xl., pages 63 to 90.

the Pitot tube, properly speaking. Mr. Dines stated that with this arrangement the influence of variations in the direction of the wind were much less noticeable. This result was interesting, but the instrument must be graduated experimentally; that is to say, that, like the Darcy instrument, it did not admit of the direct measurement of the velocity in absolute terms. The case was different for a straight tube protected with a guard-plate. In the latter case, it was certainly necessary to place the guard-plate parallel to the direction of the current; but once this was done (and it was relatively an easy matter), the pressure in the tube became equal to the static pressure of the fluid, so that the Pitot tube recorded the dynamic pressure corresponding to the velocity. Mr. Dines also pointed out with reference to his (Prof. Rateau's) experiments on an anemometer, which was caused to oscillate before two currents of air side by side, that this oscillation might disturb the measurements by producing obliquity of the air-currents towards the axis of the apparatus. This criticism had not escaped him (Prof. Rateau), and if he had not spoken of it in his paper, it was because it appeared to him that the disturbance thus produced would be negligible, or at any rate unimportant compared to the result proved by the experiments. In his experiments, the pendulum beat in $\frac{2}{3}$ second and the amplitude of its oscillation was about 4·72 inches (12 centimetres), giving a mean velocity of 1 foot (0·32 metre) per second. This was but feeble, compared to the velocity of the air-current, which amounted to nearly 62 feet (19 metres) per second. Finally, Mr. Dines did not agree with his (Prof. Rateau's) opinion as regarded the air dragged round by the arm of the testing-machine in the operation of calibrating the anemometer. Without denying that there was some action of this kind even with a very thin arm brought to a feather-edge, he (Prof. Rateau) nevertheless persisted in stating that the correction to be made under this head had been greatly exaggerated.

Mr. W. H. Dines, (Leatherhead) wrote that he had no further comment to make on Mr. Rateau's reply, excepting that for the actual velocities that Prof. Rateau had stated in the case of the anemometer swinging in the air-current, he thought that the error due to the oblique impact must be inappreciable. He still thought that the error due to the so called *mit-wind*, when anemoneters were tested indoors, rendered the final result uncertain to the extent of 2 or 3 per cent.

Mr. Charles Chree (Richmond, Surrey) wrote that whilst

appreciating Prof. Rateau's kind references to his paper in the *Philosophical Magazine*, he felt uncertain whether its relationship to the problem at issue was not somewhat obscurely stated. It was quite true that the Woltmann mill and the Robinson cup-anemometer were in many respects unlike, but it so happened that the equation obtained by Prof. Rateau for the Woltmann mill was a special form of the general equation (1) which he (Mr. Chree) had applied to the Robinson cup-anemometer. In two of the simplified forms of (1) for which he (Mr. Chree) had obtained solutions, the hypothesis that the co-efficient a_2 was zero was actually made. Whether the co-efficient a_1 vanished or not was immaterial so far as the form of the solution was concerned; the simplification could be introduced immediately in the final solution. He did not follow Prof. Rateau's explanation of the apparent contradiction between his (Prof. Rateau's) formulæ for steady and variable motion. Unless the friction of the spindle, etc., recognized as existent in the one case, really ceased to exist in the other, the omission of frictional terms was not satisfactory from a physical standpoint. Any simplification of mathematical formulæ, which was of the nature of a concession extorted by mathematical difficulties, necessarily affected the accuracy of the solution. Prof. Rateau might of course have excellent reasons for believing that the omission was under normal conditions of little practical importance, and such might be the case. At the same time, it was probable that friction was more important in some instruments, and in some forms of variable motion than in others.

Mr. Clarence R. Claghorn read the following "Description of Present and Proposed Methods of Operating Vinton No. 3 Colliery Vintondale, Pennsylvania, U.S.A.":—

DESCRIPTION OF PRESENT AND PROPOSED METHODS OF OPERATING VINTON No. 3 COLLIERY, VINTONDALE, PENNSYLVANIA, U.S.A.

By CLARENCE R. CLAGHORN.

On the eastern portion of the estate of the Vinton Colliery Company, the main workable seam of coal, locally known as the "Miller" seam, is above the water-level of the main-drainage. The topography of this portion is rugged and mountainous, and under one large hill is an isolated field of coal, the seam outcropping completely around the base of the hill (Fig. 1, Plate XVII.). This oval-shaped field contains about 550 acres of coal, being about 8,000 feet long and 3,000 feet wide. The main rise of the coal-seam is 7 per cent. in the direction of the longer axis of the field.

The seam averages 4 feet in thickness (3 feet 8 inches to 4 feet 2 inches), and is clean and free from partings of all kinds. The floor is of hard fire-clay, gradually changing as the depth increases to sandy shale. The roof is of blue metal, changing to a sandy shale. The lower 2 to 3 feet is quite hard and strong, stands weathering very well, and contains some small ironstone-nodules or balls. Above this hard shell, the roof-stone becomes more and more shelly and brittle, until it passes at 15 to 18 feet above the coal into a shaly sandrock.

The top of the hill under which this field of coal lies, is underlain by a ledge of hard sandrock, which has protected it from denudation and formed a table-land. The average cover over the coal under this flat-summit is nearly 175 feet. In this interval of strata are two seams of coal of no economic importance at the present time, being either too thin or too dirty in quality to be considered workable.

The Miller seam coal, in structure, as developed at the Nos. 1 and 2 collieries in adjoining areas, is a medium soft coal, without very well marked cleavage; that is, the butts and faces, while they can be seen upon examination, are short and very difficult to distinguish one from the other, and have very little bearing upon the direction of the mining-face.

The roof does not carry any well marked cracks or breaks, but such few as do occur come in from almost any direction. As remarked before, the lower 2 to 3 feet of the roof is hard and easily supported by simple post and cap (lid). When this hard portion is brushed down, as has been frequently done in some main haulways, the best of the roof is gone and posting (timbering) with cross-bars under shelly places must frequently be resorted to. In drawing (removing) pillars, there has been but little trouble in controlling the roof, whether under-cutting by hand or machine. The Jeffrey chain-breast machine now used in Nos. 1 and 2 collieries requires a greater space for its operation between the face and the posts than allows the attacking of the pillars as they should be attacked; *i.e.*, on end, and considerable risk is at times run in drawing pillars with these machines.

The No. 3 colliery is being developed in the field of coal before referred to, and the writer proposes to exploit the coal on a "modified longwall retreating system."

The main opening, a drift, has been made at the lower end of the field very nearly in line with its longer axis (Figs. 1 and 2, Plate XVII.). The outcropping of the coal here happens fortunately to be just about the right height, above the railroad side-tracks which were already constructed, to allow of excellent surface-arrangements. The main heading or haulway is being driven directly up the pitch or rise of the coal (7 per cent.) and will lie closely on the longer axis of the field, splitting it in half and leaving approximately 1,500 feet of solid coal on each side.

On reaching the solid coal with this main heading, two cross-headings (a fore and a back) are turned on each side, and they are driven on slightly ascending grades of about 1 per cent. toward the outcrop of the seam. At intervals of 300 feet along the main heading, similar pairs of cross-headings are again driven on the same easy grades in practically parallel directions. Longwall faces will be opened between adjoining pairs of cross-headings upon reaching the outcrop, and thus be 300 feet long. These longwall faces will be opened by turning up the pitch, and parallel to the main heading, a wide room or stall, say 40 to 50 feet wide, which will be driven until it cuts through into the next cross-heading, 300 feet above. The inner rib of this wide room will constitute the first longwall face. The wide stall having been cut through into the heading above and the advancing workings in the solid coal beyond being otherwise ready, the coal will be attacked in the rib of this wide room and withdrawn in one 300 feet face, between cross-heading and cross-

heading, towards the main-heading. It is probable that the faces will be stopped within 50 to 75 feet of the main-heading, leaving this width of coal as a barrier or pillar on each side, as a protection for the main-haulway and return air-course. It is the intention to open the first faces as far as possible, on the neutral line of the pitch, so that the pressure due to the pitch will be neither on the face nor on the gob. It is quite probable that experience will show that the coal and roof will both work better if the direction of the faces be inclined away from this neutral line in either one or the other direction and more or less weight of the roof thrown on the coal-face of the gob (Fig. 2, Plate XVII.).

Three hundred feet of face undercut 5 feet deep in this coal will make approximately 200 tons. For the present, the output will be limited to 1,200 tons from the longwall faces and 300 tons from the workings advancing in the whole coal, per single shift, so that not more than six longwall faces will be required at one time, although two or more extra faces will be developed and held in readiness for working in regular turn, in which to place the men in case of any emergency.

The greatest difficulty is anticipated in obtaining the first fall of roof, and it is the intention to be especially guarded and prepared for this. In driving up the wide rooms or stalls, *E*, (Fig. 2) preparatory to opening the faces, a roadway is carried along each rib, posting the stall in the usual manner. Upon the completion of this stall, the longwall face then being ready, the longwall post rows of timber will be set along the inner rib of the room or stall, and the old stall posting withdrawn. The first few feet of roof will be hard to break. In drawing pillars, it frequently bends down for considerable distances before breaking, while on the other hand when once broken the shelly strata above will keep it broken off close up to the post rows and the hard portion or shell immediately over the coal makes an excellent stone to post to. On the first face, if a fall does not come naturally when the face has advanced far enough to warrant it, shooting the roof will be resorted to by putting a series of drill-holes in the hard shell immediately over the coal with compressed-air drills, and firing all, or a certain number, at once by means of an electric battery. In all subsequent work, if the roof hangs beyond the limit of safety, the same method of shooting will be adopted in order to bring the roof down and make the face safe.

Development-work in driving the headings, both main and cross, is already well advanced. It is the intention to undercut entirely by machinery, and to that end a plant has been laid down using com-

pressed-air as a motive-power. At present, there is installed a Norwalk compressor, having compound air-cylinders, with a capacity of operating 12 Sullivan reciprocating pick-machines. The headings are all driven by these machines, and up to the present time not a pick has been swung in the colliery since coal was struck.

At Nos. 1 and 2 collieries, which are developed entirely on the room-and-pillar system, an electric plant for both haulage and undercutting has been operated for four years, using Jeffrey electric locomotives for main haulage, home-built electric-rope hauls for secondary haulage, and the Jeffrey chain-breast machine for undercutting; and entire satisfaction has been felt with the plant. The only pick-work or hand-hewing done in these two collieries has been to drive narrow headings for haulways where bottom has to be lifted to obtain height, and where it would not be convenient to raise the machines up on this bottom bench; and also in a certain amount of pillar-withdrawing or robbing. Hand-mined coal usually amounts to about 6 per cent. of the entire product.

While No. 3 colliery is not far distant from Nos. 1 or 2 collieries, an electric plant was not laid down in this case, because of the relative first cost, as entirely new machinery would have been required at the main-power plant, the present demands upon which have about equalled its capacity, and because the chain-breast machine is not at all adapted to longwall work, requiring as it does from 8 to 10 feet of clear space from post to face. The electrically-driven longwall machine is practically unknown in this country, and its records remain yet to be established.

The pick or percussion-machine requires, of course, a certain amount of clear space in which to set the board on which it operates, but this board can be set between the props, and the machine can be successfully worked in and around timber, ordinarily in the way of other machines. It is also much less expensive, costing not over £45 ($225), and should one inadvertently be caught, less damage is liable to be done, and the investment is not so great. The writer's experience in room-and-pillar work is that pick-machines will not cut as much coal by 40 per cent. as chain-breast machines, and are, therefore, proportionately more expensive to operate in labour costs. He had not gone so far as to be able to compare the cost of repairs per ton for the two classes of machines, as the compressed-air machines are yet new and the electric machines upwards of four years old. In this connexion it might be said that the use of pick-machines in longwall work is merely experimental and tentative until the writer has sounded and tested the local conditions, etc., and found how best to control them, after which he will probably

install at No. 3 colliery air-driven longwall machines for use exclusively on the faces, the pick-machines then being kept in the advancing workings.

The lie of the coal, taken together with the foregoing system of working, affords means of developing a somewhat novel system of underground transportation. In machine-work, where everything is pretty much all loading or filling, and a tonnage basis of payment is in force, pit-wagons must come and go rapidly so as to admit of the fillers making a good wage. The men often laughingly remark that they have to "fill and fill until the shovels get red-hot." And therein lies one of the great disadvantages of pillar-and-stall work, where the tedious movement of pit-wagons to and from the faces of the stalls, often very long, causes loss of time, and is a source of complaint on the part of the men.

It has been remarked that the main haulway is driven directly up a 7 per cent. rise. A twin cylinder, single friction drum, rope-haulage engine, fitted with powerful friction-brakes and reverse levers, is used on this haulway. This engine is located outside, some 150 feet from the drift-mouth, in line with one side of the heading. The haulage-rope is led from the drum and carried overhead, along the side of the main haulway, which is as straight as driving by sights can make it, to near the haulway-face, where it passes around a large and strong return-sheave set in a suitable frame, and thence back along the middle of the haulway-track. This return-sheave is moved forward as the face of the main-heading advances, mechanical haulage being thus maintained close to the face. The rope is carried out-bye along the side of the heading on self-oiling sheaves, and back in the middle of the track on cast-iron rollers. The grades are quite sufficient for the loaded trip to pull the rope off the drum, being always kept under control by means of the reverse levers or brake, while the engines are used to pull the empty trip up the grade into the mine. The system is thus a modification of a simple engine-plane. Similar plants on a smaller scale are in use at the other collieries for secondary haulage, and great satisfaction has been derived from their operation.

As before indicated, each face will produce about 200 tons per shift, and 15 men will be required to fill this coal in from 8 to 10 hours, each man filling 13 wagons. On the main-rope haulage, it is proposed to run trips of 50 wagons, 15 wagons being destined for each of three longwall faces and 5 wagons for the workings advancing into the solid coal. Electric-bell signals have been installed in the main

haulway, and by using the 220 volts power-circuit from No. 1 power-station, signals are both rung and flashed (by means of incandescent lamps) in the engine-room.

In serving the longwall faces with their quota of pit-wagons, the lower heading of each pair of cross-headings will be used as the haulway for the empty pit-wagons destined for the longwall face next below it, while the upper heading of the pair will be used as a haulway for the loaded wagons coming from the longwall face next above it.

Throughout this entire section, animal haulage is performed entirely by mules, these being found stronger and hardier than horses or ponies, and better able to stand the rough usage of the mines. They soon become accustomed to mine work and to their own particular duties. If handled properly they make most efficient animals for underground haulage. Those used in these collieries stand 54 inches high, and weigh nearly 850 pounds.

As all cross-headings will seek and be driven on easy grades favouring the loaded wagons, it is not felt that the tonnage of coal coming from each of the longwall-faces will warrant the laying down of any system of secondary mechanical haulage on the cross-headings. At least one attendant will be necessary on each pair of cross-headings, and it is deemed advisable, for the present at least, to depend upon animal haulage rather than instal a rope or motor.

The coal-seam being but 4 feet high, it is necessary to lift 18 inches to 2 feet of bottom in order to lay more or less permanent tracks for tram-roads in the cross-headings and to obtain sufficient height. No bottom will be taken up along the longwall-faces, where sections of track will be laid directly on the floor of the coal, the rails being bridled and braced together, so that they may be easily shifted with the advancing face.

On the main-heading, a substantial road is being laid, using steel rails weighing 40 pounds per yard. In all other tracks, throughout the colliery, a lighter section of rail is used, weighing 12 pounds per yard, the lightest section which experience shows to be sufficiently stiff to stand up under the loaded pit-wagons.

When a trip of 15 coupled wagons is delivered to the lower one of a pair of cross-headings by the main haulage-rope, the mule-driver on this heading will haul them at once to the turn of the longwall-face, where they will remain until required along the face, or when the trip of 15 wagons distributed along the face and being loaded is ready to be dropped to the upper of the pair of cross-headings at the other end of

the face. The loaded trip when so dropped out on the heading will be hauled by the driver of this pair of headings to the main entry parting, ready to be picked up by the main haulage-rope and delivered at the bank. The pit-wagons will thus make a complete circle around the long-wall-face and when loaded will always move down grade in the direction of gravity. It would appear that, with this arrangement, there being no reverse movement of the wagons, it will be possible to place the greatest number of wagons along the face, to be filled with the utmost system and regularity and least labour and confusion.

By means of a cross-over tippler and a circle of track at the tipple, the door-ends of the wagons will always be kept in the right direction. The drivers attending the cross-headings, it can be seen, will thus draw the loaded trips of wagons down the light grades of one heading, returning with the empty trips of wagons on the adjoining heading, without loss of time, and will be enabled to pass from one heading to the other by means of cross-cuts located at convenient intervals. Each driver will handle, with one animal, 200 tons per day with ease at a cost of ¾d. (1·5 cents) per ton, while prices are as at present for labour and upkeep of live stock.

Some difficulty has been foreseen in handling the pit-wagons on the comparatively heavy grades of the faces. If the brakes be set or all four wheels of the wagons be spragged, it is quite possible for them to run away on the iron tracks, especially when loaded. It might be possible to hold the wagons in position during filling by means of blocks placed under the wheels or some such device, but it would be impossible to move them from place to place by hand or to drop them to the loaded heading at the lower end of the faces. Inevitably there would be a runaway with consequent damage to wagons, props knocked out, roof let down and possible injury to life or limb. To obviate this, and to properly control the movement of the wagons along the face, small and simple devices have been constructed consisting of a small cast-iron drum fitted with a friction-brake, mounted in a timber frame, set on skids and held in position by means of a chain attached to a post. This drum holds 300 feet of ½ inch wire-rope fitted at the loose end with an open socket-and-link. This appliance will be moved forward with the face, and is kept in position in line with it. The trip of wagons will be left coupled and while passing around the curve, from the cross-heading to the face, the rope will be attached to the end car, and by the application of the drum-brake the wagons will always be under perfect control and the whole trip can be dropped past the face or

stopped and held at any point at will. After the wagons have been filled with coal and dropped to the loaded cross-headings, the wire-rope will be rewound on the drum by means of a crank-handle on one end of the drum-axle and thus be ready to attach to the next trip of wagons.

It is the usual custom throughout this district to pay a stipulated price per ton, known as the district price, for all work connected with the hewing, getting and filling of the coal; the work of the hewer, getter and filler being performed by one person. The miner in addition to performing these operations furnishes his own powder and supplies as well as tools, and often trams his wagons to and from the face, lays the room-track, sets the posts, and generally cares for the place in which he works, under the supervision of a certificated mine-foreman. Where machine undercutting is practised, the only difference made in the payment is that, the coal being undercut for the miner, he is paid a less price per ton for his work, generally $\frac{5}{9}$ or $\frac{2}{3}$ of the pick-price, and he continues to get and fill the coal as well as care for his place as in hand-work.

The practice at No. 3 colliery will be to undercut and get the coal and care for the face by separate arrangement. Thus the most experienced and capable men in these operations can be employed. Fillers will only need a pick and shovel apiece, and each man can regulate his pace to suit himself, so long as he does not delay the general progress, and no one man can claim preference to any coal by reason of having got it down. Were the getting and filling to be combined, each man would be required to possess his shooting tools, including auger, scraper, tamping-bar and needle, as well as powder, squibs, paper and cartridge-stick. The resulting confusion can be readily imagined.

Tonnage prices throughout the district are quite well established by custom, and are based entirely on the conditions obtaining in room-and-pillar work. Any innovation as to method is looked upon askance by the workmen, if these customary prices are likely to be affected. It has been necessary to move slowly in the matter of fixing compensation for the workmen, not wishing to give away entirely such advantages as come from a successful change of methods.

Among the advantages foreseen under the proposed system might be enumerated :—

(*a*) The work will be concentrated and the filler stimulated by personal competition.

(*b*) The pit-wagons will circulate immediately at the face and will be loaded "side on," a very great advantage.

(*c*) No coal will have to be handled twice to fill in a wagon, as almost always happens in room-and-pillar work.

(*d*) No tramming, in general, will be required, as one or two of the face-men will attend to the control of the trip of wagons along the face by means of the drum before mentioned. This in itself is of the greatest advantage, as tramming the wagons to and from the faces of the room is a source of lost time and of discontent.

(*e*) If the roof be properly controlled, less labour and explosives will be required in getting the coal than in room-work.

(*f*) The filler will not be compelled to lay track and post his place.

The class of labour now found throughout the coal-mining section of this country is much inferior to that of 10 or 15 years ago. It is fully 60 per cent. non-English speaking, and but a small portion of the men ever saw a coal-mine before landing in the States. Not a few are utterly unfitted to be left to work alone in the mines. As we are obliged to do the best that we can under the circumstances, it is necessary to take the material at hand and work it to the best advantage, and it is the general opinion that the labour we have, under the guidance of competent leaders, will do better on longwall than room-and-pillar work.

The colliery pit-wagons weigh 1,300 pounds when empty, and carry from 2,000 to 3,000 pounds of coal, the gross weight being thus 3,300 to 4,300 pounds. They are 9 feet long, over all, but cover 10 feet of track when the coupling-links are stretched. They are 48 inches wide at the extreme flare of the sides and stand 25½ inches above the rail at the top of the door-rod. The wheels are of self-oiling pattern, waste-packed, and run loose on the axles. They are 16 inches in diameter, and weigh 85 pounds each. The wheel-base is 26 inches, and it enables the wagons to pass around quite sharp curves. The gauge of the track is 36 inches while the gauge of the wheels is 35¼ inches. The sides and bottom of the wagons are constructed of white-oak planking, bound together by four iron bands or "binders." The front end of the wagon is fitted with a gate through which the coal is emptied when dumped, and each is provided with a brake sufficient in power to skid all four wheels.

With the exception of the main-heading, all the headings are what are locally known as "gob-headings," that is, the coal is taken a little wider than the width actually required for the passage-way, in order to

provide space in which to stow the bottom fire-clay lifted for height in the roadways. Double rows of posts are set on the gob-side of such headings to make all secure. The main-heading rocks are loaded out, making neater and tighter but more expensive work.

The compressed-air pipes are carried near the roof on one side of the roadway. The main line, 4 inches in diameter, is carried along the main back-heading. Tees are placed in this line at the junction of one pair of cross-headings, and mains 2 inches in diameter, are carried to the face. A line of 1½ inches pipe, with tees and cocks at intervals of 50 feet, will be carried along the longwall-faces, from which the machines will draw their air. The connexion of the 1½ inches face-pipes with the 2 inches cross-heading pipes will be made with 10 feet of air-hose, affording a flexible connexion and admitting of the face-pipe being shifted with the face and a length of cross-heading pipe taken out at one time.

Contours on the floor of the coal vary to some extent as might be expected. Hence the cross-headings in seeking grades will approach or recede from one another, making the longwall faces correspondingly longer or shorter than 300 feet as planned in theory. This will cause the face-tracks to be made longer or shorter to correspond. In order to do away with all pieces of short rail, a flexible connexion will be made by using an ordinary tee-rail turned upside down and laid against the outside of the track-rails so that the flange of the reversed rail fits over the ball or head of the other, thus making a sliding or flexible joint, the whole when in position being held by iron bridles with wooden wedges.

The surface arrangements including the bank-house or "tipple" (as the structure contains the weigh-scales, tippler and chutes is known in this country) possesses some unique features.

From the drift-mouth to the tipple, all landing and yard-tracks have a descending grade of 2 per cent. in favour of the loaded wagons. On this grade, with tracks laid of 40 pounds rails, wagons will quickly start themselves from rest. The tippler is of the cross-over type. The wheels of the on-coming wagon, just before reaching the main-frame of the tippler, strike and depress a hinged section of rail which, by means of toggle-rods and levers, opens out the tip-horns, allowing the empty wagon which has just been dumped to run forward over the head of the chute on the fore-rails. The loaded car continuing forward by gravity passes off the hinged-section of rail which by means of springs is returned to its position, bringing back the tip-horns in time to catch the loaded wagon and hold it in position during the dumping operation. The rear end of

the tippler is fitted with a powerful brake operating on a sword, by means of which the movement of the tippler can be regulated and controlled at will.

The position of the wagon on the tippler is such that, when loaded, the centre of gravity is over the rocker-arms and when the brake is released the tippler revolves downward. When the wagon has been emptied of its coal, the rear end of the tippler is the heavier and rocks back into position. The forward end of the tippler is provided with eccentric shoe-like lugs which operate the short section of rails spanning the chute-opening and known as the fore rails, rolling them onward when the wagon is dumped so that, being wider than the track-gauge, it can roll downward to the angle required to spill the coal.

Beyond the tippler, the empty wagons pass by gravity over 2 per cent. grades for 200 feet, and thence on $1\frac{1}{2}$ per cent. grades to the bottom of the collecting-pit, which is accessible to the main-haulage rope.

Immediately back of the tippler are located a pair of extra heavy and strong safety-horns, operated by a foot-lever placed next to the levers controlling the tippler. At the back of the safety-horns, again, is placed a set of standard weigh-scales in such a position that when a trip of wagons is landed against the safety-horns one wagon stands exactly on the scale-platform.

These weigh-scales are fitted with the ordinary double beam, and have in addition a quick-weighing attachment, by means of which weights varying within 10 cwts. are registered on a dial. On one beam the standard wagon-tare is registered, while on the other the beam-weight is set for the tare of the standard wagon. If a wagon weighs more than 20 cwts., and less than 30 cwts., the excess over 20 cwts. is indicated on the dial and may be noted by the attendant. All pit-wagons must be loaded within these limits, in order that the filler may obtain a proper credit: no wagons containing less than 20 cwts. of coal being credited, nor is any excess over 30 cwts. allowed.

The tipsman regulates the tip-lever with his left-hand, records the wagon-weights and check-numbers with his right hand, and operates the safety-horns with his foot. A man and boy on the top are all that are required to handle 1,500 tons per day.

Let us assume that a loaded trip has been landed by the haulage-rope against the safety-horns and is thus standing on a 2 per cent. grade. The boy begins at once to uncouple the wagons, and to take off the fillers' brass tokens or checks which hang on convenient ticket-hooks on the outside of the wagons. In doing this, he writes, with chalk, each check-

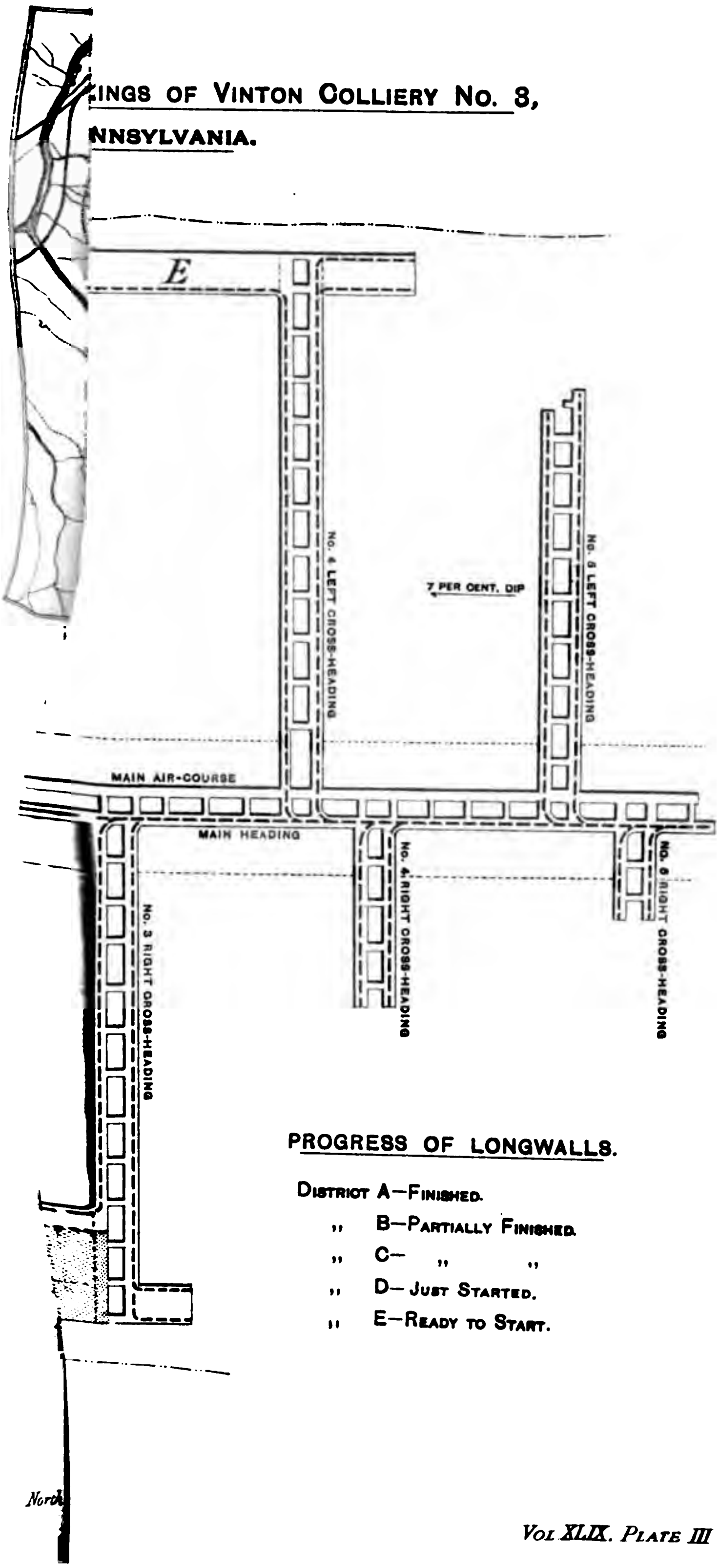
number on the side of the wagon where it may be seen by the tipsman as it passes him, previously rubbing off any old check-numbers which may be thereon with a piece of waste or cloth. As soon as the first car or two are uncoupled the dumping of the trip of loaded wagons can begin.

The tipsman opens the safety-horns by pressing the safety-horn lever with his foot and a loaded wagon runs forward by gravity on to the tippler, replacing, as before described, the empty wagon standing thereon. While this wagon is being dumped (and the record is 120 wagons in 30 minutes) the whole loaded trip feeds itself forward against the safety-horns on the 2 per cent. grade, so that by the time a wagon has been emptied of its coal and the tippler returned to position another wagon is against the horns ready to be let through. A simple lock prevents the opening of the safety-horns unless the tippler is in place.

These appliances save the services of one and possibly two extra men, and, while the tipsman must keep his wits constantly about him, his work is comparatively easy. The boy, having uncoupled the loaded wagons and noted the fillers' check-numbers thereon, goes over to the empty-track side and couples up the empty wagons as they come together on the down-grade, so that the trip of empty wagons will be ready when required by the main-haulage rope.

No explosive or noxious gases are found in any of the collieries in this section, and naked lights are therefore exclusively used.

Mr. A. L. Steavenson (Durham) said that the condition of the coal-seam, 4 feet thick, was extremely favourable and probably they would not find anything like it in Great Britain. The ironstone of Cleveland had a very soft shaly roof with strong freestone above. When they began working in Cleveland in 1862 or 1863, it was thought that the ironstone would bear anything, and they began with walls 24 feet long and bords 12 to 15 feet wide; but the soft shale fell down and boxed in the pillars. Was the room-and-pillar system referred to in the paper the same as the the bord-and-pillar system? The writer referred to the use of Sullivan pick-machines, and seemed to také it for granted that the members knew all about them, but as a matter of fact they did not know anything about them. Pick-machines had been tried in this country, but their use had been abandoned on account of the opposition of trade-unions. Nothing was said in the paper as to the price paid to the coal-hewer. It was stated that the work would be divided between the coal-hewer and filler: this should be the true aim of mine-managers, and he would like to


...INGS OF VINTON COLLIERY NO. 8,
...NNSYLVANIA.
E
NO. 4 LEFT CROSS-HEADING
NO. 5 LEFT CROSS-HEADING
7 PER CENT. DIP
MAIN AIR-COURSE
MAIN HEADING
NO. 3 RIGHT CROSS-HEADING
NO. 4 RIGHT CROSS-HEADING
NO. 5 RIGHT CROSS-HEADING
PROGRESS OF LONGWALLS.
District A—Finished.
" B—Partially Finished.
" C— " "
" D—Just Started.
" E—Ready to Start.
North

see it enforced throughout this country. He asked whether the barrier, left to maintain the roads, was recovered.

Mr. F. R. SIMPSON (Ryton) said one of the most interesting points of the paper was the proposed method of bringing the tubs to one end of the face and running them out at the other end. It would be difficult to maintain the tub-road along the working-face unless the roof was exceedingly good.

Mr. R. A. S. REDMAYNE (Seaton Delaval) said that the method of working home from the boundary to the shaft was not a familar method in this district, and he hoped that in three or four years, Mr. Claghorn would communicate a further paper on the subject. It appeared that a compressed-air plant had been erected to work the reciprocating pick-machines, and he thought that compressed air was most suitable for working these machines, although he understood that a large number were electrically worked in the States, and he would like to know the writer's reasons for adopting compressed air in opposition to electricity.

Mr. PHILIP KIRKUP (Birtley) said Mr. Claghorn appeared to advocate a modification of the longwall system, which seemed suitable for working a clean seam. He considered that there would be a dicuffilty in maintaining the roof at the working-face, as the space occupied by the loose coals, the tramway and the standing timber next the goaf will be considerable. He noted that on the main-heading, steel rails were used weighing 40 pounds to the yard, and in cross-headings and along the the working-face a lighter rail weighing 12 pounds to the yard is used. This seemed to him an unusally light section of rail to use for a tub carrying 27 cwts., and having a tare of 10 cwts. He enquired what was the section of the rails in use?

Mr. T. E. FORSTER (Newcastle-upon-Tyne) said that, some years ago, at a colliery in Northumberland, roads were driven to the boundary with the intention of commencing at the boundary and working the coal in an out-bye direction. It was however, found impossible to keep a road open along the face, and the coal was eventually worked off by judding over. As in this case, everything would depend on the nature of the roof.

Prof. H. LOUIS (Newcastle-upon-Tyne) said that, as it was proposed to operate this colliery almost entirely by percussion pick-machines, one was bound to resort to the use of compressed air to drive machines of that type, as no electrical pick-machine had yet proved itself efficient.

Mr. W. C. Blackett (Durham) said that he had been favourably impressed with the suggestions made in Mr. Claghorn's paper. They were of a more or less feasible nature, and he should imagine that the writer would not have much difficulty in carrying them out in practice. The writer seemed to contemplate very little difficulty in upholding the roof at the working-face, and members would notice after the writer had provided for all the room that he required, both for the timber and machines, that he contemplated having some difficulty in getting the roof to fall, and he actually proposed to shoot the roof-stone in order that he might relieve the weight at the face. And, after all, it would not take, with the great care which the writer had used, a great deal of width next to the working-face to provide the necessary space.

During the last few weeks at one of his own collieries, he had contemplated working one of the seams almost parallel in every instance with the method described in the paper. The seam that he had in his mind was situated under a hill, with a similar quantity to work, and with a slight rise, of which he proposed to take advantage by using endless ropes. In that particular seam, the roof was extremely bad, but still he had hopes of being able to adopt a similar method, if they could afford time to wait for the formation of coal gateways. There was another seam that he was convinced he would not be able to work on account of the extremely bad roof, unless it was worked in some such manner as that suggested by Mr. Claghorn. In another instance, the roof would not allow of a double width of way for the endless rope, and the empty tubs were conveyed inwards on one narrow road, and the full tubs were brought out by another narrow road with a thin coal-pillar, 9 feet thick, between the roads.

Mr. John Southern (Heworth Colliery) remarked that at Heworth colliery, pillars 120 feet wide were driven for a length of 200 feet, and then worked out-bye, 60 feet being worked to each road, and the roof remained firm. There was no difficulty whatever in getting the tub along the working-face. The thickness of the seam was 6½ to 7 feet, including a stone band, 20 inches thick, which was thrown back into the goaf. He asked the writer why the curves to the branch-roads were laid in a reverse direction.

The President (Mr. W. Armstrong) said that the use of an ordinary pick-machine which had been at work at Hetton collieries in the Low Main seam had been abandoned because it was impossible to maintain it in working order.

Mr. C. R. Claghorn, replying to the discussion, said that he came to England for the purpose of studying longwall working, which was not practised in America, except in rare instances. A few mines in the southern part of Illinois and Indiana were operated on the advancing longwall system; the undercut was made in the floor, the waste-rock was stowed in the goaf, and the roof gradually settled down.

The ordinary method of working by the pillar-and-room system had been illustrated in the *Transactions*.* At the Vinton collieries, the hewers put their own tubs, kept their room in order, laid their own tracks, and were paid 2s. a ton.

The tubs were heavy, weighing about 13,000 pounds with 16 inches wheels, self-oilers, refilled once in 2 months. They used heavy tubs because locomotive haulage was used, and the cars had to be very strong. He had been very much struck with the small size of the tubs used in the Durham coal-field. The tubs stood about 25 inches above the rail. They were filled bed-full with small coal, and then filled up with larger coal until they just about touched the roof. In that way they worked larger coal in some cases than he had observed in the North of England, where he had seen hewers break large lumps to get the coal on the top of the tub. In Pennsylvania, the tubs were very wide, with a gauge of 36 inches. He had asked at a number of English collieries whether it would be difficult to keep the roof at the face, so as to leave a road along the coal-face, and he felt very much encouraged by the answers that he had received. A three-phase electric mining-machine had been introduced, but there was not one in operation to-day. It was well constructed and well designed, but was not successful in operation.

The common practice in Pennsylvania was to use a heavy T-rail for the main heading and light rails in the rooms, even as low as 8 pounds per yard, but ties were inserted at intervals of 18 inches, so that much lighter sections of rail could be used. The 40 pounds rail was about 4 inches, and the 12 pounds rail about 2 inches high. The 40 pounds rail was adopted, so as to secure a stiff track for locomotive haulage.

About a year ago, a pick-machine was in use, operated electrically, in which the blow was struck by a spring, the motor running continuously with a cam, which withdrew the pick or the part which struck the blow. The blow could be regulated by means of the spring, but as the machine weighed 1,000 lbs., they were never able to make much use of it. In another mining-machine of the percussive type, three brushes were used, but it did not work satisfactorily.

* *Trans. Inst. M.E.*, vol. xvii., plate II., page 178.

The turns into the cross-headings were reversed, and as the trip of cars were run past the cross-heading, the cars of the trip were dropped into the cross-heading. Locomotive haulage was in use at No. 1 mine, because the main heading was driven water-level. He thought that locomotive haulage offered more flexibility than any other system, as the line could be extended every day or so, if desired. The thickest cover on the seam did not exceed 175 feet.

Fully 60 per cent of the workmen were unable to speak English.

Mr. W. C. BLACKETT said that plenty of coal was worked on the pillar-and-stall system in Durham, where coal was worked close under the outcrop, and the roof was very friable.

The PRESIDENT said that if the roof was allowed to stand too long, it would be a menace to the working-face, and when the area was too great for the timber, the roof would fall near the face, knock the timbers out, and cut off the face.

The PRESIDENT moved, and Mr. W. C. BLACKETT seconded a resolution according a hearty vote of thanks to the writer for his interesting paper.

Mr. J. J. Muir's paper on the "Ore-deposits of Mount Lyell, Tasmania," was read as follows :—

ORE-DEPOSITS OF MOUNT LYELL, TASMANIA.

By J. J. MUIR.

The copper-field of Mount Lyell, in the island colony of Tasmania, is now so widely known in the mining world that it is unnecessary in this paper to describe at length its geographical position.

The great metalliferous belt follows the general line of upheaval of the west-coast range of mountains, which, on a north-and-south course, are at a mean distance of 15 miles from the seaboard. The rocks of these mountains may be classed in two main divisions, and the cleavage-plane between these two systems marks the line of metalliferous deposition. This fact has now been so clearly recognized, especially as regards the massive lenticular ore-deposits, that all exploratory work, both to the north and south of the Mount Lyell field, has been confined to it.

The geological subdivision of the main systems of rocks is as follows :— On the eastern side of the metalliferous belt, lies a vast zone of red sandstone-conglomerates, dense, hard and chiefly unstratified rocks. This great area of red rocks has been defined by visiting geologists as the Devonian system of Old Red Sandstone ; but so far as the writer is aware no palæontological evidence has been adduced in support of the assumption.

In conjunction with these rocks on the west, occurs an undetermined area of schists and quartzites in various stages of metamorphism. Over a large surface whose extent is not yet determined, these latter rocks are more or less metalliferous. The ore-containing rocks occur in alternating zones or bands, and, so far as yet explored, the talcose schists appear richer in copper than the quartzites.

When these rocks were originally laid down in their horizontal position, it can now be demonstrated from exploration-work that the metals held in solution were more liberally distributed in the schists than in the quartzites. A very marked and an invariable feature is that the more nearly the junction with the sandstone-conglomerates is approached the richer become the ore-containing rocks. This culminates on the junction-line between the two systems in the lenticular ore-masses now being worked by the two chief mines of the field.

The schists and quartzites, which may be described as the ore-bearing rocks of the field, are well stratified, and as a consequence of their upheaval from the horizontal position now dip at an angle of from 80 to 85 degrees. The underlay of these rocks agrees with that of the ore-deposits and metalliferous chutes in the country-rocks.

It is a noticeable fact that in mostly all explored deposits and ore-chutes a regular ascending ratio of ore-value is obtained from the hanging to the foot-wall, the gravitation law in original deposition being uniform. A vital point in the geology of the western ore-rocks is frequently overlooked by mine managers, and often leads to confusion and waste of money. The continuity of the metalliferous chute is interrupted at intermittent intervals by the unconformability of stratification, the original cause being cross-courses in the cleavage-planes formed during the upheaval. On the other hand, the sandstone-conglomerates constitute a platform on which the ore-bearing strata have been laid down. These rocks being devoid of metal-contents in themselves (except in one isolated exception) are from their hardness regarded as a serious obstruction to mining operations.

The exploration-work that has been carried out in the western deposits has resulted so far in the proving of large masses of ore-bearing rocks, with copper-values varying from 2 up to 10 per cent., and the usual bye-products of gold and silver in small quantities.

These ventures are now confronted with the problem as to how they can produce individually and independently a payable concentrate for export. One mine has erected concentrating machinery on an elaborate scale for treating the metalliferous rocks in bulk, and in the writer's opinion the conditions are highly favourable to a successful result.

It is a noteworthy circumstance that, along the junction-line of the two rock-systems, massive outcrops of hæmatite occur at more or less intermittent intervals. Geologists have maintained that this ore has been derived from the decomposition of pyritic bodies, and that they are the visible sign of the abundant sulphide ore-mass which they overlie and cover. The fallacy of this theory has now been amply demonstrated by development and exploration-work. It has been proved beyond doubt that these deposits of hæmatite are not necessarily derived from hidden pyritic bodies, although they occur along the main junction-line on which the large ore-deposits are discovered.

So much has been written, about the large deposit of pyritic ore now worked by the Mount Lyell Mining and Railway Company, by the highest authorities in copper metallurgy that a passing reference

to it need only be made in this paper in comparing it with the other ore-deposits of the field. As is wellknown, the lenticular mass of iron-pyrites, carrying copper, gold and silver in payable quantities, is, according to various writers, in no way essentially different from similar deposits profitably mined in Spain and elsewhere. It would also appear from reports on the mines that their mode of geological occurrence is similar.

It will be seen, therefore, from the foregoing remarks that the ore-deposits of the Mount Lyell field occur in two forms:—(1) Lenticular masses in concentrated form at the contact of the conglomerates and schists; and (2) areas of metalliferous rocks, occurring in chutes and zones in the form of copper-pyrites, and associated with the schists and quartzites.

About 1½ miles along the contact-line from the Mount Lyell mine, the next great discovery in the field was made on the property of the North Mount Lyell Copper Company, Limited. The ore-channel was systematically followed up, and resulted in the discovery of a unique mass of copper sulphide. It is a body of dense bornite and chalcocite (copper-glance) in a matrix of quartzite, and ranges in assay-value from 15 to 35 per cent. of copper. The whole mass, which is about 180 feet in length by 80 feet in breadth, lies in direct contact with the foot-wall of conglomerates, and has been traced in depth to 350 feet. The difference between the composition of this ore and that of the Mount Lyell mine at once marked an unique discovery for the field, as hitherto iron-pyrites, carrying copper, gold and silver had alone been considered. The North Lyell discovery, therefore, introduced a new class of copper-ore, in the richness of its copper-contents it has not been locally surpassed, and in the writer's opinion is very unlikely to be.

Continuing about 2 miles further north along the junction-line valuable discoveries are being made on the Lyell Comstock mine, and as the geological conditions are analogous to those existing at the North Lyell mine, there is high probability of rich concentrated deposits being discovered thereabouts in the near future.

The President moved that a hearty vote of thanks be accorded to Mr. Muir for his interesting paper.

The motion was cordially approved.

Mr. E. Halse's paper on "Some Silver-bearing Veins of Mexico,' was read as follows :—

SOME SILVER-BEARING VEINS OF MEXICO.

By EDWARD HALSE.

INTRODUCTION.

The following descriptions are mainly based on observations made by the writer from 1891 to 1895, during which years he visited several of the classical mining-camps of the Republic of Mexico, and examined some silver-bearing deposits hitherto little known, as they are situated far from the beaten tracks. It must be understood that the veins in the lesser known districts are described from a geological rather than from an economic standpoint, for it is certain that many of them would not pay to work at the present price of silver.

The writer has endeavoured to confine himself to facts, and has eschewed theories on the origin and history of the veins, for although later developments cannot alter the phenomena met with at the surface or at moderate depths only, they might considerably modify any attempt to explain the genesis of the deposits.

THE CHIPIONEÑA SILVER-MINE, NEAR MATAPÉ, STATE OF SONORA.

This mine is in the district of Ures,* some 25 miles south-south-east of the town of that name, 16 miles north of Matapé, and 84 miles east-north-east of the Torres station of the Sonora railroad. The mine is situated on a line of low hills skirting the plains on which the town of Matapé has been built, the elevation being about 3,000 feet above sea-level. The hills form a portion of a granite-belt stretching in a general north-and-south direction from Ures in the north to San Marcial in the south, or a length of about 70 miles. The rocks immediately surrounding the granite are modern eruptives, excepting about 4 miles to the north-east, where a mass of Jurassic limestone crops out on the western slope of the Sierra de Santiago. At the surface, the granite, which is whitish, has quite a solid appearance, but in reality it is considerably altered and is so tender that it can be readily broken up by the hands.

The vein of the Chipioneña mine crops out on the south-western side of the granite-hills trending in a general north-west to south-east direc-

* The traveller visiting this region should go provided with top-boots or a thick pair of leggings, as rattlesnakes abound, and have an awkward habit of going to sleep in the roads and paths just before sunset.

tion, and dipping to the north-east 45 degrees. The strike varies locally from north 35 degrees west to north 57½ degrees west, and the dip from 38 to 50 degrees. The granite forming the walls is stained a deep red, and a microscopic examination of the "country" shows the felspar to be altered and charged with iron-oxide. It is somewhat greasy to the touch and is locally known as *tucurababi.**

The main joints or "beds" form a very acute angle (from 5 to 10 degrees) with the lode in the line of strike, and dip in the same direction as the vein at the same angle or sometimes a few degrees steeper. Other joints cross these nearly at right angles, and have a high north-westerly dip. Fig. 1 (Plate XVIII.) shows the relative positions of the veins and the two sets of joints as seen in plan, the thick lines representing the lode coursing in altered granite.

The vein is from 3 to 4 feet thick and can be traced at the surface for about 4,000 feet. The filling at and near the surface is white, red, and yellow-stained quartz and country-rock, with oxide of iron and unaltered iron-pyrites. The surface-ore would appear to be poor, judging from the *terreros* dumped on the hill-side, a sample of which yielded only 5 ounces of silver and 16 grains of gold per ton.

On the eastern side of the hill, a shaft or adit-level (*socabon*), inclined 30 degrees from the horizon,† had been sunk until it had cut the lode about 114 feet from the surface, measured on the incline, or at a vertical depth of about 52 feet. It had been worked upwards and downwards very irregularly from this point, in fact in the zig-zag fashion peculiar to shallow Mexican mines. Altogether the mine had been worked about 200 feet, measured on the dip of the vein, or about 141 feet vertical.

About 52 feet from the surface, measured vertically, the lode is 4 feet wide, 2 feet consisting of good ore on the hanging-wall side. The vein in the centre is well mineralized (thickness 1 foot), while the portion lying on the foot-wall (1 foot in thickness) is of low grade.

The hanging-wall dips 48 degrees and the foot-wall 49 degrees. Elsewhere on the same horizon, the best ore lies on the foot-wall side (thickness 2 feet), indeed this is generally the case in this mine.

Fig. 2 (Plate XVIII.) is a typical cross-section of the vein on the same horizon. Next the hanging-wall is a gouge of clay about 6 inches thick, then comes a 12 inches leader of quartz with silver-bearing

* This is evidently an aboriginal name and was probably given by the Apaches, who formerly mined in this region.

† This is an example of what is known in some parts of Spanish America as a *chiflón*, or work making way in length as well as in depth.

sulphides of lead, iron and zinc: 15 inches of country-rock with stringers and spots of mineral separates the latter from the pay-streak or *cinta* which lies on the foot-wall. The pay-streak is here only 4 inches in thickness, and consists of limonite and quartz showing native silver.

This is an example of considerable alteration on one side of a lode, while the opposite side consists of quartz with undecomposed sulphides; in other words, the zone of sulphides here overlaps the oxidized zone. The two mineralized portions of the vein are separated by country-rock which is clearly *in situ*, and not a horse or portion of country-rock which has been broken off from one of the walls.

Further westward still on the same horizon, the vein is only about 2 feet in thickness, but is well mineralized on the foot-wall side, the oxidized pay-streak varying from 6 to 18 inches in thickness.

At the bottom of the mine (141 feet vertical), the red gossany pay-streak is replaced by a rib of sulphide-ore, 6 inches thick, in which iron-pyrites predominates. The mineral on the hanging-side (dip 38 degrees) is from 20 to 27 inches thick, while there is but a thin film of clay or selvage on the hanging-wall.

The vein, as a rule, is very uniform in strike, dip and thickness; it has well defined walls, usually with clay-selvages. The hanging-wall is sometimes seen to be in rolls or short curves. The ore occurs in shoots or chimneys pitching north-westward, and between them the lode-filling consists of soft clay with crystals of iron-pyrites embedded in it, having little or no silver. On the other hand, the crystalline iron-pyrites (*bronce*) found in the payable portion of the lode contains silver up to 500 ounces per ton.

The pitch of the ore-shoots appears to have been determined by the joint-planes of the country-rock described as crossing the lode and dipping in a north-westerly direction (Fig. 1, Plate XVIII.).

At first sight, it would appear that the joints are of more recent date than the lode itself, but it may be that the mineral solutions gradually replaced the country-rock, and in so doing failed to obliterate the joint-planes. It has already been shown that near the centre of the lode a portion of country-rock exists, only partially mineralized. On the other hand, the fact that the ore-shoots pitch in a north-westerly direction is no evidence that the joints were formed before the lode, for these joint-planes would naturally give access to surface-waters, the circulation of which would tend to redistribute the ore in the lode itself.

The joints and the clay-gouge existing on the hanging-wall of the lode appear to afford evidence of a horizontal movement having taken place in the country-rock, but whether before, after, or at the same time as the lode was formed is not clear.

SILVER-REGION OF TAVICHES, NEAR OCOTLAN, STATE OF OAXACA.

This region is about 5 leagues from Ocotlan, and 11 leagues from the city of Oaxaca, in a south-easterly direction. It measures roughly about 8 leagues in length following a north-west to south-east direction by 2½ leagues in breadth. The district is very mountainous, forming in fact a spur of the Cordillera, known further north as the Sierra Madre, and is broken up by deep gullies (*barrancas*), more or less parallel to the general direction (north-west to south-east), and by shallower gullies (*quebradas*) perpendicular to it. The elevation above sea-level varies from 4,075 feet to about 6,080 feet.

The formation is eruptive, mainly hornblende-andesite of Tertiary age, and is limited on the east by the calcareous formation (Cretaceous), and on the west by the Huronian rocks of Ocotlan.

The structure of the andesitic country-rock varies considerably, being in some places massive, in others distinctly bedded, and here and there showing a tendency to become prismatic. In its normal condition, it is a hard rock showing white or greenish crystals of hornblende (amphibole) and darker coloured crystals of hypersthene; frequently it assumes a red, purple, green, blue or white colour, according to the degree of alteration, or the amount of foreign elements present in the rock. The extreme of decomposition or alteration results in an almost pure white clay or kaolin.

The andesitic country-rock is traversed by a number of veins, the chief ones of which run in a general north-west to south-east direction. Some of the veins are remarkable for their great thickness—in some instances measuring upwards of 300 feet across the outcrop; for their length—often being traceable for several miles; and for the strength of their outcrops, which here and there stand up like walls from 20 to 30 feet above the general surface of the ground.

Parallel to these veins, there would appear to be a system of felsitic dykes, which is especially noteworthy in the north-eastern portion of the district. Indeed, it is highly probable that some of the larger veins will on further exploration prove to be dykes strongly metalliferous in places.

Another system of veins crosses the first, trending in a general east-

and-west direction. These are not so powerful as the first system, they are usually in the nature of bedded veins, and were probably formed long before the north-west to south-east system of fractures. They are in places well charged with silver-ores.

The filling of the veins varies considerably in different parts of the region. Where the veins are wide the ore runs in ribs, bands or *cintas* parallel to the walls, often alternating with layers of altered country; elsewhere the ore has a tendency to occur in small bunches (*ojos*). Indeed some of the veins at and near the surface show quartz with isolated grains or *moscas* of pyrargyrite (*rosicler-obscuro*).

Gossans (*colorados*) predominate as a rule near the surface, consisting of oxide of iron, with one or more of the following:—oxide of manganese, chloride of silver, more rarely native silver, blue and green carbonates of copper, and finely disseminated native gold in quartz or altered country-rock. The wider the vein, other things being equal, the deeper does the oxidized zone penetrate; but, where the veins have a hard and compact filling right up to the surface, sulphide-ores may exist even to the grass roots, as in the instance quoted above.

The configuration of the ground sometimes determines the existence or otherwise of the oxidized zone; thus, in the case of a vein crossing a valley of erosion, the water-level may exist immediately below the bottom of the valley, in which case the probabilities are that the oxidized zone will be absent although such a zone may occur in the hills on either side of the valley.

In certain places, the ores are strongly charged with iron-pyrites close up to the surface; but, as a rule, that mineral is by no means conspicuous, and is often entirely absent.

The general matrix is quartz, from white to yellow in colour, generally crystalline and more or less transparent, and sometimes crystallized in vughs or druses and on clay-joints and partings. In certain veins or portions of veins, it has a characteristic concentric radiated structure, showing that the quartz had filled, and crystallized out, in cellular spaces in the rock. In proof of this, such cellular spaces exist here and there without any filling.

With the quartz often occurs calcite, and occasionally gypsum.* With the silver ores (mainly pyrargyrite or dark ruby silver, sometimes associated with proustite or *rosicler claro*, polybasite or argentite), stibnite is not infrequently found. Other associations are iron-pyrites, galena (argentiferous when fine-grained), copper-pyrites and blende.†

* Fluorspar is also said to occur sometimes.
† Rhodonite is said to have been found also.

Most of the ores contain a certain proportion of gold—the percentage varying from a few grains up to, in rare instances, several ounces per ton, and appearing to increase in a northerly direction.

In the southern portion of the district much greater denudation has taken place than in the northern portion, while, as a matter of fact, the ores known as *negros* predominate in the former, and in the latter *colorados* nearly always constitute the upper portions of the veins. There are, of course, exceptions to the rule. This will serve to explain the increase in the percentage of gold northward, for ore generally carries more free gold in the oxidized zone (*colorados*) than it does in the zone of sulphides (*negros*).

The sketch-plan (Fig. 3, Plate XVIII.) was made by the engineers of the Mexican company working this district. It has no pretence to accuracy, but is intended to give a rough idea of the general direction of the chief lodes of the district.

Las Mujeres.—The main vein has a normal north-west to south-east* course, and dips south-west 40 to 55 degrees. Workings on a north-and-south branch dipping west 45 degrees show several feet of vein exposed, consisting of quartz, oxide of iron and iron-pyrites, with a *pinta* of sulphides of silver, etc.

El Conejo.—This is a powerful vein, parallel to and a little east of the last. The general trend is north-west to south-east, and the dip south-west 50 to 60 degrees. The outcrop (*creston*) rises from 18 to 20 feet above the ground, the hanging-wall being distinctly visible, while the foot-wall is concealed by *débris* from the outcrop. The thickness must be from 20 to 30 feet at least. At the time of the writer's visit (December, 1894) the bottom workings, about 100 feet in depth, were mostly under water. One small pit (*cata*) exhibited 8 feet of quartz and white altered rock, with oxide of iron and specks (*pintas*) of sulphide of silver.

A little north of the *hacienda*, galena, blue and green carbonates of copper and oxide of iron are associated with the silver-ores. The latter often occur in rounded masses or *ruedas*, as they are termed locally. Here the lode has a north-and-south branch, dipping west 45 degrees. To the south of the *hacienda*, the gold is finely disseminated in the vein, and is associated with galena, generally fine-grained,

* All readings are magnetic, the declination being 7° 30′ east.

but sometimes in large cubical crystals. In places, the lode consists of a number of thin parallel quartz veins separated by hard country-rock, and is probably a mineralized dyke, metalliferous in places.

The ore containing gold is ground in an *arrastre*,* and treated by the *patio* process. Fig. 4 (Plate XVIII.) is a sketch of a hand-arrastre (*arrastre de mano*†) used by the Indians of the district. The grinder or upper millstone is made of very hard andesite from the neighbourhood, and is worked by means of two wooden handles wedged into the stone. The bed or lower millstone consists of a similar hard stone set in a clay-basin or mortar. It is hardly necessary to point out that the grinder rotates on an iron peg fixed in the centre of the bed—it is, in fact, a variation of the ancient Roman mill of which many fine examples, found in Northumberland, have been preserved by the Antiquarian Society of Newcastle-upon-Tyne.

The above powerful vein can be traced in a north-westerly direction as far as the Yavola Hill (probable distance 3,300 feet). The rock there is seen to be considerably altered, and of a mottled red-and-white colour. In the depression between the two hills, the outcrop takes a westerly bend (due to the dip of the vein) before reaching this point. To the south-east of the above workings, the vein splits up into three branches, the most easterly of which runs north-and-south. Below this point in a deep *arroyo*, and beyond, on a rounded hill to the north-east of San Geronimo, the vein is again seen to crop out powerfully. Here it is known as "Creston Santa Cruz." At this point the vein has its normal north-west to south-east trend, and the dip is south-west 55 degrees. The hanging-wall stands from 30 to 40 feet above the general surface, and the thickness is 30 feet at least. Stibnite occurs in this outcrop. Still further south-eastward, another powerful outcrop of probably the same vein is seen on the road leading from the eastern part of the district.

Santa Catarina and Chivo.—This is the highest part of the district (6,080 feet above sea-level). Several parallel veins have been worked here containing *cintas* of silver-bearing quartz. The principal outcrop trends about north-west for the greater part of La Soledad and Santa Catarina claims; it then deviates considerably from this general direction, running almost east-and-west in the Dios Guia claim to the east. The strike for the greater part of the workings is north 38 degrees west

* This is almost invariably spelt *arrastra* in English works, but the above is the correct spelling of the word; it is derived from the verb *arrastrar*, to drag along.

† It is similar to the *maray* used in the Argentine Republic, but is much smaller.

to south 38 degrees east, with a high south-westerly dip. In one place where two veins united, the ore-body was nearly 50 feet thick (15 metres).

In another instance, very rich ore was met with in an east-and-west vein dipping north, 21 inches thick, at a point where three other veins or branches formed a junction with it, the first two striking about north 35 degrees west, and the last north 20 degrees east.

The lowest workings are about 260 feet in depth. The ores are *colorados* or peroxide of iron, yellow ochre (these two resulting from the decomposition of limonite), and quartz with sulphide of silver. The ore shoots across the lode obliquely with a southerly pitch—a phenomenon of not infrequent occurrence in this district. The best ore seems to be in No. 2 level. In No. 3 (bottom) level, as well as in the greater part of No. 1 level, the filling consists of very soft rock, being white clay (altered andesite), bespattered with crystals of iron-pyrites. It is needless to say such workings are unpayable (*en borrasca*).

*San Francisco.**—This mine is a little east of San Geronimo. At the mouth of the workings the vein trends nearly east-and-west and dips south 25 degrees. Inside, the vein bends round to from 30 to 60 degrees northward and dips south 30 degrees. An ore-shoot (*clavo*) has been followed here to a depth of 50 or 60 feet, which seems to be in the nature of a chimney. The shoot crosses the lode somewhat obliquely, for whereas the lode here strikes north 30 degrees west to south 30 degrees east the pitch of the shoot is directed south 40 degrees west (Fig. 5, Plate XVIII.). A rib or *cordon* of the vein being worked is nearly 4 feet thick on an average, and consists of quartz showing a good *pinta* of sulphide of silver, and with small rhombohedral crystals of calcite. The bottom of the mine could not be examined, as it was under water at the time.

Las Animas.—This is close to the last and is possibly an extension of that vein. The vein strikes east-and-west, dips south 45 degrees, and is 22 feet in thickness. The filling shows small rhombohedral crystals of calcite similar to those in the last vein. In one place a *cordon* of ore is composed of 4 feet in thickness of quartz and oxide of iron, with some inclusions of white altered "country."

La Soledad is a little further down the *arroyo*. The vein strikes north-west to south-east and dips south-west 55 to 60 degrees. Both

* The strike of the vein is not shown correctly in the plan.

sides (*relices*) of the vein exhibit white altered kaolinized rock. A rib from 2 to 3 feet thick consists of white and bluish quartz with some oxide of iron, and inclusions of white altered "country."

The rock in the neighbourhood is hard andesite with a bedded structure, the layers running north 22 degrees to 30 degrees west, with an easterly dip.

*San Bartolo.**—A wide vein crops out, trending north 80 degrees east, and dipping south 80 degrees, of ribs of ore separated by more or less barren rock. The quartzose and highly ferruginous filling is spotted with sulphide of silver.

Minas Viejas.—This is a shallow working a little south of the last, on a north-west to south-east almost perpendicular vein. The thickness is from 2 to 6 feet; the ore, however, is confined to a rib of about 15 inches on the north-east side, consisting of quartz with some oxide of iron, spotted with sulphide of silver and crystals of iron-pyrites.

On the road, between the last and San Geronimo, the rock is seen in one place to have a bedded structure.† The beds trend east and west, and dip high to the south.

Providencia.—In an *arroyo* on the road to the veins purple and green beds of hard andesite trend west-north-west and dip north 38 degrees.

The Providencia vein runs east and west nearly, and dips northward at and near the surface, which changes to southward below. The vein is very soft and the ore very red and earthy. In an *arroyo* a little south of the last, a parallel vein courses east-north-east and dips south 70 degrees, consisting of branches of quartz and gossan in white altered rock. La Purissima vein, near the above, runs east-north-east with a high southerly dip. The ore is very red and earthy, showing spots of sulphide of silver in quartz.

The country-rock of these veins, generally speaking, is purple andesite, in beds having the same strike and dip as the veins themselves, hence the latter would appear to be bedded veins.

Santo Tomas.—This vein trends north-west to south-east and is several feet thick. In the upper workings, the "country" is a soft purplish rock, in which the vein has a somewhat flat south-westerly dip. Lower down, the rock becomes very hard, and the vein is almost

* The strike of the veins is shown incorrectly on the map.
† *Ibid.*

perpendicular. The hanging-wall side consists of quartz, calcite and iron-pyrites, and is spotted with sulphide of silver. The rock is a light green andesite, with some dark green discolorations, in beds trending north-west to south-east and dipping south-westward, so that this vein is also a bedded one.

San Juan.—This vein is a little south of the last and runs west-north-west to east-south-east with a southerly dip. There are old opencasts (*tajos abiertos*) here. The vein is 5 feet wide, with a rib of gossany ore on the hanging-wall; 3 or 4 other ribs consist of quartz separated by altered "country" having dark green discolorations. Marcasite occurs in this vein.

Several veins form a junction at the Trinidad mine and produced a *bonanza*.

Santo Niño.—The general direction of the vein is north 25 degrees west with a westerly dip, and the thickness is 35 feet. The filling is chiefly quartz. The ore is pyrargyrite (*rosicler-obscuro*), and occurs in spots (*moscas*) or in little bunches (*ojos*) which appear to cross the vein obliquely and to pitch south. It is known as *metal mosqueado* in the district, and occurs right up to surface.

The ore, when brought to the surface, is hand-picked by Indians,* and divided into (1) *pepena* or first class ore, (2) *pinta* or second class, and (3) very low-grade ore, which, with the waste (*tepetate*), is thrown on the dump.

Another remarkable feature about this vein is that it is crossed by a series of clearly-defined joints trending north 22½ degrees east to south 22½ degrees west, and dipping south-south-eastward 48 to 57 degrees, which divide the vein up into a number of separate ribs crosswise to the general strike, thereby more or less obliterating the original bands or ribs of quartz and ore parallel to the walls. These joints are doubtless of later origin than the vein-filling, and may be evidence of recent horizontal thrusting having taken place in the country-rock; nevertheless, they have probably had considerable influence on the final arrangement of the ore in the vein, and help to explain the oblique distribution of the bunches or *ojos* (Fig. 6, Plate XVIII.).

The quartz-filling here and there shows an amygdaloidal structure, having included black fragments of andesite (?). Calcite is also present.

* Native labour is scarce but cheap, Indian *barreteros* or miners being paid 37½ cents (silver) per day, while *barreteros* imported from Guanajuato or Zacatecas receive $1 (silver) per day.

An interesting mineral specimen from this mine shows needle-like crystals of quartz, about 4 inches in length, springing from a base of argentite (SAg_2). On the surface of the quartz-crystals are numerous bleb-like excrescences of quartz, each bleb being formed of a number of minute prismatic crystals. The large crystals of quartz have a background of uncrystallized carbonate of iron, forming a sort of double-shield, oxidized above (where the quartz crystals are stained red), and scattered with small rhombohedral crystals of calcite.

San Angel.—This working is on a hill to the north within the *pertenencia* known as "Corazon de Jesús." The width exposed is 12¼ feet. The ore is in *moscas* of pyrargyrite in quartz showing a radiated spherical structure, a piece of the former mineral (*petlanque obscuro*) sometimes forming the centre. The ore is associated with stibnite, calcite in large greenish rhombohedral crystals, and gypsum. The gangue appears to be formed of hard andesite with flat layers of calcite, 3 to 9 inches thick, forming vughs or druses. Moreover, it is veined with quartz (also forming vughs here and there), and in places exhibits layers of somewhat hard red clay scattered with small transparent crystals of selenite.

Joints cross the lode in a similar way to the last.

San Joaquin.—This is further north than the last, but on the same line of fracture. The vein strikes north-north-west and dips westward 55 degrees at the bottom of the working, and 35 degrees at the top. Hard andesite forms the hanging-wall; and the foot-wall consists of rock altered to a red clay separated from the vein by a layer of what appears to be quartzite. Joints cross the lode and dip at a high angle south, but in this instance they have not obliterated the original bands of mineral parallel to the walls.

The ore, with an average thickness of 3 feet, is pyrargyrite scattered in quartz (*mosqueado*), but is more evenly distributed in the gangue than in Santo Niño, and is associated with some blue and green carbonates of copper. A sample of the best ore (*pepena*) yielded 233·32 ounces of silver and 0·08 ounce of gold per ton; one of the *pinta* variety gave 77·87 ounces of silver and 0·20 ounce of gold per ton. A sample taken right across the face assayed 30·33 ounces of silver and 0·1 ounce of gold per ton. The waste gave only about 2 ounces of silver per ton.

La Cueva.—This is a little north of San Joaquin. The vein runs a little west of north, and dips westward 50 degrees. A natural hole or cave follows the course of the vein for about 60 feet, and is 22 feet in width. On the eastern side, a working goes in 12 feet, and has exposed about 3½ feet of ore consisting of small *moscas* of pyrargyrite in white opaque or transparent quartz. Near the mouth of the cross-cut about 2 feet of better-class ore is associated with stibnite. The quartz here also exhibits the spherical radiated structure observable in San Angel. The ore is hand-picked into *pinta* and waste. Limestone forms the eastern wall of this deposit.

It must be understood that the workings of Santo Niño, San Angel, San Joaquin, and La Cueva are not all on the same vein, although they are on the same line of fracture. In Corazon de Jesús, the vein is split up into several curved branches (mainly on the eastern side) which appear to unite both north-and-south—a phenomenon of frequent occurrence in the larger veins of the Republic (*e.g.*, the *veta grande* of Zacatecas, the *veta madre* of Guanajuato, and, in a lesser degree, the Vizcaina vein of Pachuca).

On the road leading in an easterly direction from San Pedro, an immense outcrop of quartz is seen close to the northern boundary of the Corazon de Jesús claim. It measures 330 feet across the general strike. The separate branches would appear to be united here in one enormous mass. Further north, in the Bitite claim, the vein again throws off branches on its eastern side, and in these stibnite* occurs in small lumps or pockets. A little west of Corazon de Jesús the rock has a thin-bedded structure, the strike of the layers being north-north-west and the dip south. An adit-level driven some distance below the above workings has penetrated limestone, the occurrence of which below the andesite cannot fail to throw considerable light on the genesis of the deposits.

Between Bitite and Esmeralda, the country is soft, and is in thin beds trending west-north-west and dipping north-north-east. Further west the dip changes to west-south-west.

Ascencion.—A vein here, 5 feet thick, courses north-west to south-east and dips north-eastward 50 degrees. There is a band of ore, 12 inches thick, on the hanging-wall, and another smaller one on the foot-wall. The filling is highly altered rock with gossan and some dull opaque quartz of a bluish tint.

* The ore was being mined by *gambucinos*, antimony metal selling in the city of Oaxaca at $2·5 (silver) the *arroba* of 25 lbs., or $200 per short ton.

A sample of the hanging-wall band gave by assay 23·33 ounces of silver and 0·12 ounce of gold per short ton. Further north, the vein bends round to west-north-west.

*Salinas.**—A west-north-west to east-south-east vein, dipping south 60 to 65 degrees, 3 to 4 feet thick, has a pay-streak on the hanging-wall 8 to 9 inches thick, which assays up to 200 ounces of silver per ton. The rest of the filling consists of soft kaolinized rock. The country-rock here has a bedded structure, the layers striking west-south-westward and dipping flatly to the north, but it appears to be much contorted.

Guadalupe.—This working is a little to the west of San Francisco (*bis*). The vein trends north-north-westward, with a high dip to the east. The filling is soft whitish and greenish altered rock. A *cinta*, 7 inches thick, of *mosqueado* lies on the east wall, while on the opposite side there is a 3 inches layer of similar ore.

Sixty feet further west is a parallel vein or branch, 15 inches thick, with a very soft filling. The east wall has a *cinta* of *mosqueado*, 5 to 8 inches thick, widening below. About 100 feet further north on the same vein, there is a split caused by a lenticular mass of hard rock. The leader is several inches thick on the hanging-side and 1 inch or so on the foot-wall side of the horse. The ore is *mosqueado* in white and brownish quartz, forming druses. The rock is very hard and of a grey colour, stained with oxide of iron. It shows no embedded crystals of hornblende, and appears to be a felsite.

A little farther west there is a big outcrop of what appears to be a dyke of felsite trending north-west to south-east and dipping south-westward.

Still further west the "country" has a bedded structure, with a general north-north-west to south-south-east direction, and a flat easterly dip.

Mesquital.†—A vein with a somewhat sinuous course, general trend east-and-west, and a northerly dip, occurs in a light greenish rock, exhibiting here and there deep blue and green stains. In places it is white and felsitic. The vein is composed of sinuous threads of ore dipping north 70 degrees. A little further west a vein is seen trending north-north-westward and dipping west-south-westward. The threads of ore here vary from a knife-blade to 2 or 3 inches thick. The quartz

* The strike of the vein is shown incorrectly on the map. † *Ibid.*

of the vein is white, with brownish discolorations. The "country" here trends west-north-west, and dips southward.

*San Rafael.**—The rock here is similar to the last. There is a *cinta* on the hanging-wall side, but the ore appears to be in veinlets of brown quartz, with oxide of iron. The trend is west-north-west to east-south-east, and the dip south; near by the "country" has the same strike and dip.

Farther south, in a rocky cañon, on the road to the San Antonio river (4,075 feet above sea-level), the "country" is in hard thick beds trending north-north-west to south-south-east, and dipping south 45 degrees. Near the river, on the east side of the cañon, the beds are thinner and less hard, the strike being north-west, and the dip north-east.

San Francisco (*bis*).—Here three parallel veins occur, only one of which had been exposed to any extent at the time of the writer's visit.

This vein had been sunk on 70 feet to the dip. The strike is north-west and south-east, varying locally to west-north-west and east-south-east, and the average dip is north-east 45 degrees, varying locally from 40 to 52 degrees. The filling is, more or less, soft mineralized rock.

The hanging-wall is unusually well defined, with slickensides and a clay-selvage, sometimes dry and hard, sometimes wet and soft, and here and there strongly impregnated with oxide of iron. The wall rolls somewhat. The slickensides are not quite vertical, but dip at a very steep angle to the north-west, showing that the movement on the wall has been a somewhat oblique one.

On the foot-wall side, the vein is harder and contains some calcite and small cubical crystals of iron-pyrites. The "country" on this side exhibits a light-coloured felspathic base in which are embedded small light greenish crystals of hornblende, the whole being highly charged with iron-pyrites.

The vein at and near the surface consists of *colorados*. On the hanging-wall side are two ribs of oxidized ore, each 6 inches in thickness, separated by 6 inches of "country." In the bottom of the shaft (70 feet on the dip) there is but one *cinta* on the hanging-wall side which shows a slight *pinta* of silver sulphide. The ore would appear to be changing here into the class known as *negros*. Between the two classes of ore (*colorados* and *negros*) the filling is confused, consisting of soft

* The strike of this vein is not shown correctly on the plan.

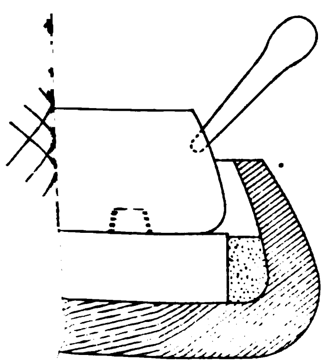
highly altered rock with black stains and patches, and with some oxide of iron and quartz.

The nearest parallel vein to the east dips 45 degrees and has a *cinta* of oxidized ore 15 inches thick.

The veins of San Francisco (*bis*) appear to be of the class known as "fissure-veins," and are quite distinct in appearance from the other deposits examined in this district.

The PRESIDENT moved that a hearty vote of thanks be accorded to Mr. Halse for his valuable paper. He might add that Mr. Halse had contributed many papers to the Transactions.

The motion was cordially approved.



...an Hand-Arrastre.

... Feet to 1 Inch.

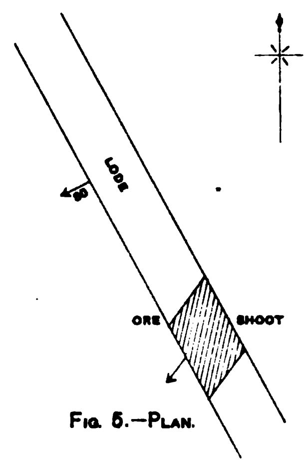
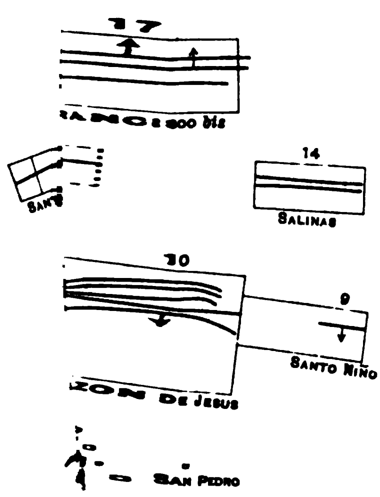


Fig. 5.—Plan.



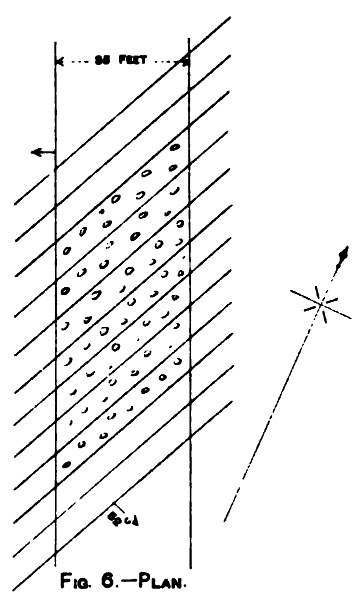
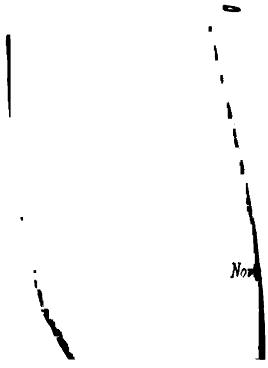


Fig. 6.—Plan.



THE MINING INSTITUTE OF SCOTLAND.

TWENTY-THIRD ANNUAL GENERAL MEETING,

HELD IN THE HALL OF THE INSTITUTE, HAMILTON, APRIL 12TH, 1900.

MR. JAMES T. FORGIE, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The SECRETARY read the Report of the Council as follows :—

COUNCIL'S REPORT.

The Council have pleasure in submitting their twenty-second annual report, embracing the proceedings of the Institute from April 13th, 1899, till this date.

The members of the different grades are as follows :—

Honorary Members	3
Life Members	8
Life Associate Member	1
Members (subscription £2 2s.)	154
Members (subscription £1 5s.)	209
Associate Members	20
Associates	7
Students	13
Non-federated Life Member	1
Non-federated Members (subscription £1 1s.)	23
Non-federated Members (subscription 10s.6d.)	15
Total ...	454

A comparison with last year shews :—

On the roll at April, 1899		468
Added during the year		12
Total ...		480
Died	7	
Retired	4	
Cut-off through non-payment of subscriptions	15	26
At present on the roll ...		454

The falling off in the membership is entirely due to the unusually small number of additions during the year, as the number of retirements is below the average.

In common with institutes of a similar kind throughout the country, this Institute has had fewer papers of late than formerly. The papers with discussions thereon which have been published during the year are as follows :—

"Notes on Hamilton Palace Colliery." By Mr. J. S. Dixon.

"The Probable Duration of the Scottish Coal-fields." By Mr. R. W. Dron.

"Endless-rope Haulage at Lethbridge Colliery." By Mr. W. D. L. Hardie.

"Machine-mining and Pick-mining compared." By Mr. W. D. L. Hardie.

"Explosions of Fire-damp and Coal-dust in the West of Scotland." By Mr. T. H. Mottram.

The annual excursion to Hamilton Palace colliery was attended by about 120 members, who had every facility given them to examine this colliery, which is one of the largest of the modern collieries of Scotland. A description of its leading features appears in the year's *Transactions*.

Your attention is directed to the published report of your delegate to the Conference of the Delegates of Corresponding Societies of the British Association for the Advancement of Science at Dover in September, 1899. One branch of work undertaken is the registration of photographs of geological interest, and a large number of photographs have already been obtained and mounted; but many more should be got, as some parts of the country are poorly represented. The Geological Photographs Committee have in view the publication of sets of typical photographs illustrative of geological phenomena, if sufficient support be given to the scheme. Sixty photographs or lantern-slides, with descriptive letterpress, will be supplied to annual subscribers of £1 1s. to £1 10s. at the rate of 20 per annum.

The donations received during the year were as follows :—

Donors.	Donations.
Mr. Joseph Dickinson ...	Paper on Subsidence caused by Coal-workings.
Mr. J. M. Ronaldson ...	Report of H.M. Inspector of Mines for West Scotland, 1898. District Statistics I., Colonial and Foreign Statistics, IV.
Mr. Henry Aitken ...	A small book on Colliers.
Mr. J. W. Howard ...	Address on Engineers' and other Institutes.

The number of exchanges is now 63, and these form an increasingly valuable portion of the library. The library catalogue has been revised and reprinted during the year.

The Treasurer's accounts shew that the Institute is in a satisfactory financial condition.

It is with regret that the Council have to record the sudden death of

one of their members, Mr. Robert Weir, who held office for a year and whose name stands in the list for re-election.

There have been seven meetings of Council during the year.

The PRESIDENT (Mr. J. T. Forgie) in moving the adoption of the Council's Report, commented on the fact that while the membership of the Institute was not decreasing, it was not increasing in any substantial form. In so active a centre of mining as Scotland the Institute ought really to have an increasing number of members every year.

The adoption of the report was agreed to unanimously.

The SECRETARY read the annexed abstract of the Treasurer's accounts for the year, duly audited.

THE TREASURER IN ACCOUNT WITH THE MINING INSTITUTE OF SCOTLAND
FOR THE SESSION 1899-1900.

RECEIPTS.		£	s.	d.
To Balance brought forward		191	2	6
„ Subscriptions —				
7 Members, Session 1898-99 ...	at 42s. 0d.	14	14	0
9 „ „ „ ..	at 25s. 0d.	11	5	0
3 „ „ „ ...	at 4s. 0d.	0	12	0
1 Student „ „ ...	at 25s. 0d.	1	5	0
1 Non-federated Member „ ...	at 21s. 0d.	1	1	0
134 Members, Session 1899-1900 ...	at 42s. 0d.	281	8	0
189 „ „ „ ...	at 25s. 0d.	236	5	0
19 Associate Members „ ...	at 42s. 0d.	39	18	0
8 Associates „ ...	at 25s. 0d.	10	0	0
10 Students „ ...	at 25s. 0d.	12	10	0
22 Non-federated Members „ ...	at 21s. 0d.	23	2	0
13 „ „ „ ...	at 10s. 6d.	6	16	6
1 Member, Session 1900-01	at 42s. 0d.	2	2	0
4 „ „ „	at 25s. 0d.	5	0	0
„ *Transactions*, &c., sold		0	13	4
„ Rents of Hall		3	13	0
„ Interest on Deposit Receipts		4	7	4
		£845	14	8

PAYMENTS.	£	s.	d.	£	s.	d.
By The Institution of Mining Engineers ...				398	8	4
„ Printing, Stationery, & Postage of Circulars				38	12	0
„ Books and Bookbinding				16	15	3
„ Rents of Halls				15	9	6
„ Gas and Assessments				2	14	5
„ Stamps, Carriages, Telegrams, etc. ...				10	5	11
„ Sundry Payments				4	9	1
„ Cleaning Hall				4	19	0
„ Expenses of Council				25	11	2
„ Salaries				93	8	0
„ Balance in Bank	235	0	5			
„ „ in Treasurer's Hands	0	1	7			
				235	2	0
				£845	14	8

Hamilton, March 29th, 1900.—Examined, compared with vouchers, and found correct.

DAVID TODD,
WM. WILLIAMSON, } AUDITORS.

Messrs. David Todd and William Williamson were thanked for their services as auditors.

The following gentlemen were elected by ballot :—

MEMBER—

Mr. ARTHUR WM. GEMMILL, Thio, New Caledonia.

STUDENT—

Mr. HUGH DOBBIE, 208, St. Vincent Street, Glasgow.

ELECTION OF OFFICE-BEARERS.

The PRESIDENT declared the following office-bearers duly elected for the session 1900-1901 :—

PRESIDENT.

Mr. JAMES T. FORGIE, Bothwell Collieries, Bothwell.

VICE-PRESIDENTS.

Mr. CHARLES T. GEDDES, 21, Young Street, Edinburgh.
Mr. JOHN GEMMELL, 10, St. Andrew Square, Edinburgh.
Mr. JAMES HAMILTON, 208, St. Vincent Street, Glasgow.
Mr. JAMES HASTIE, Greenfield Colliery, Hamilton.

COUNCILLORS.

Mr. THOMAS ARNOTT, Fernbank, Newton.
Mr. JAMES BAIRD, Auchincruive Colliery, Prestwick.
Mr. ADAM BROWN, Allanton Colliery, Hamilton.
Mr. DOUGLAS JACKSON, Coltness Iron Works, Newmains.
Mr. ROBERT M'LAREN, Bonny, Uddingston.
Mr. JOHN MENZIES, Auchinraith Colliery, Blantyre.
Mr. DAVID M. MOWAT, Summerlee Iron Works, Coatbridge.
Mr. ANDREW PEARSON, Balvaird, Rutherglen.
Mr. MICHAEL ROSS, Bog Colliery, Larkhall.
Mr. THOMAS THOMSON, Eddlewood Colliery, Hamilton.
Mr. JAMES WYPER, Townlands Colliery, Hamilton.

The PRESIDENT in returning thanks for the honour which the Institute had again conferred upon him, said that he appreciated most cordially the consideration which the members had shown him in the past. He would continue to endeavour to further the interests of the Institute.

On the recommendation of the Council, Mr. James McPhail, Carron Works, Falkirk, was nominated as a Councillor in room of Mr. Weir, deceased.

DISCUSSION OF MR. T. H. MOTTRAM'S PAPER ON "EXPLOSIONS OF FIRE-DAMP AND COAL-DUST IN THE WEST OF SCOTLAND."*

Mr. GEORGE A. MITCHELL (Glasgow) thought that it was a mistake on the part of H.M. inspectors of mines to assume the attitude that they sometimes did in connection with the retention of safety-lamps after they had been introduced. As matters stood at present, once safety-lamps were introduced into a mine they were kept there practically for all time coming; and, in consequence, managers were tempted to take extra risks to avoid the introduction of the safety-lamp. If it was understood that safety-lamps could be taken out when it was thought that there was no necessity for their being retained, managers would not be tempted to involve themselves in these extra risks. The figures in Mr. Mottram's paper were certainly startling, and he was inclined to think that the proper course would be to enforce the present regulations, and not to introduce new rules. In the proposed new rules it was suggested that if an ignition of fire-damp once took place, safety-lamps, for all time coming, were to be used in that mine. He did not know that this was the proper place to discuss the new rules, but he thought that this proposed rule went too far, and moreover would not necessarily prevent accidents. It would, he thought, be most interesting to have statistics as to whether there were many cases in which more than one explosion had occurred at different times in the same colliery in which naked lights were used. If statistics showed that such collieries might have a slight explosion, and then not another for a very long period, then the enforcement of the use of safety-lamps would serve no good purpose.

MR. JAMES S. DIXON (Glasgow) said that Mr. Mitchell had raised a very important point in regard to the introduction of safety-lamps. This matter was at present *sub judice*, and in consequence, it might seem a little irrelevant for the members to discuss it, but at the same time, there was a good deal of force in what had been said. The use of safety-lamps was brought very prominently before a manager when a colliery was being opened: the manager being afraid to introduce safety-lamps, in case they might be regarded as a permanent institution. There ought to be some *modus operandi* by which safety-lamps could be withdrawn from a colliery when their retention was considered to be

* *Trans. Inst. M. E.* 1899, vol. xviii., pages 186 and 325.

unnecessary. There was no doubt that safety-lamps mitigated the number of small burning accidents in collieries, and this fact was evidenced by the almost complete immunity from such accidents, which collieries working with safety-lamps at present enjoyed.

Mr. Mitchell observed that, according to law, safety-lamps might be taken out of a colliery, but in practice it was extremely difficult to get them taken out when once they had been introduced.

Mr. T. H. Mottram did not think that there was a law to the effect that safety-lamps could not be taken out of a colliery. He had known instances where safety-lamps were used, and subsequently withdrawn; but where they had been introduced at the instance of one of H.M. inspector of mines, he expected to be informed before they were withdrawn.

The President (Mr. J. T. Forgie) stated that about 20 years ago a serious explosion occurred at Barrwood colliery, Kilsyth, resulting in the loss of 17 lives. After the explosion, the pit was immediately put on safety-lamps, which were withdrawn some six years later, without H.M. inspector of mines having been consulted on the point. At a later period, the inspector requested that safety-lamps should be re-introduced, and the question was referred to arbitration. As the members knew, it was difficult to enter upon an arbitration which would end favourably to the coal-master. If a coal-master urged that safety-lamps should be taken out of a colliery, after it had been decided by arbitration that they should be introduced therein, he must revert to a further arbitration to get the original finding overruled if possible. He did not think that there should be a hard-and-fast rule in a matter of this kind.

Mr. T. H. Mottram, replying to the discussion, said that at the last meeting Mr. R. W. Dron had suggested that the mid-day inspection ought to be performed by an independent person. He thought that such a proposal would meet with considerable opposition, because the fireman was already in the mine, and he was the proper person to make such an inspection. He believed that at one time a Special Rule existed in Scotland requiring two inspections to be made during the course of each shift, and although this rule had been abrogated, some managers still made two inspections, believing that reducing inspections to a minimum was neither economical nor desirable. At the last meeting, he (Mr. Mottram) had adduced figures to show that at a few collieries in which safety-lamps had been introduced in the West of Scotland, accidents by falls of roof had diminished; and he had made inquiries to ascertain

how far this reduction could be supported by experience in other mines-inspection districts. Mr. J. S. Martin, in his annual report, on the South-Western district for 1898, published a table which, to use his own words, "goes in support at a glance." In 1875, only 1,755 safety-lamps were in use, and 34,136 persons employed. In 1898, the safety-lamps had increased to 21,726, the persons employed to 46,471, while the mineral raised per life lost by falls had increased in round numbers from 244,000 to 396,000 tons. He (Mr. Mottram) had been informed by Mr. Martin that the workings were now much deeper, and in the steam coal-seams in a much greater proportion—where there was more gas and worse roofs—than was formerly the case when the upper seams were those principally wrought. Mr. A. H. Stokes said that, taking two large mines with a poor roof in the Midland mines-inspection district, during 8 years with naked lights, one life was lost by falls for every 340,745 tons of coal raised—whereas with safety-lamps in use, during a similar period, the output per life lost increased to 373,845 tons. In the 16 years, nearly 10,000,000 tons were raised, and Mr. Stokes said that this instance was a good test, for they had practically "the same workmen, the same mine, the same roof, and in every respect similar conditions." He had also taken a large group of mines with inferior roofs, but all working the same seam of coal, and for 10 years—during which time about 23,000,000 tons were raised—the drawings per death from falls of roof and sides were: with safety-lamps, 319,363 tons; mixed lights, 222,334 tons; and naked lights, 278,482 tons. This statement showed a higher tonnage per death from falls in safety-lamp pits than in collieries where open lights were in vogue. He would also refer members, who took an interest in the subject of "safety-lamps *versus* open lights," to Mr. J. S. Martin's annual report for 1894 and to Mr. A. H. Stokes' annual reports for 1889, 1890 and 1891, all of which were worth reading. Over 70 per cent. of the coal in the Midland mines-inspection district was obtained by the use of safety-lamps, and not a single death from explosions of gas occurred during 1898 and 1899. He thought that these figures, in addition to those already given applying to the West of Scotland, established the fact that the use of safety-lamps in place of open lights did not mean an increased death-rate from falls, but on the contrary, a probable decrease consequent upon improved discipline in the mine. In his experience he had found that accidents from falls did not occur from want of light; but, in the majority of cases, through failure to prop the roof. The statement that the ratio of accidents from falls would have shown greater improvement in recent years but for the increased use of safety-lamps was

based on slender evidence, for in all cases, so far as he knew, facts showed the opposite. Mr. J. T. Forgie suggested that the General and Special Rules might be condensed, so as to make them more easily understood. So far as Special Rules in force in Scotland were concerned—after comparing them with those in force in other districts—he thought that they contained little superfluous matter, particularly those relating to fire-damp. He thought, however, that Mr. Forgie's suggestion might be acted upon by printing the Special Rules affecting fire-damp on the inside cover of the daily report-books.

Mr. MITCHELL asked whether it was not the fact that accidents from falls had materially decreased both in pits where naked lights and in those where safety-lamps were used. If such a decrease had taken place, then Mr. Mottram's statistics were of little value. He did not say that the inferences drawn were wrong, but it seemed possible that they were so. Figures must be very carefully dealt with as it was possible to be greatly misled by statistics.

Mr. T. H. MOTTRAM replied that, in the cases which he had instanced in the West of Scotland district, a decrease in the number of accidents from falls had followed the use of safety-lamps in place of naked lights, in a greater proportion than was the case in the other parts of the district.

Further discussion of the paper was adjourned.

DISCUSSION OF MR. R. W. DRON'S PAPER ON "THE PROBABLE DURATION OF THE SCOTTISH COAL-FIELDS."*

Mr. GEO. A. MITCHELL thought that the paper was one of great interest, and Mr. Dron seemed to have spent an immense amount of time over it. Of course his figures could not be anything more than rough estimates, but he thought that they had been made on very fair lines, and his conclusions might be taken as fairly accurate. The paper was opportune at this time, when so much was said about the probable exhaustion of our coal-fields. The members would recollect that Mr. J. A. Longden last year gave an address of a very pessimistic character† in which he stated, taking Mr. R. T. Moore's figures, and bringing them down to date, that the easily worked Lanarkshire coal would only last about twelve years. He (Mr. Mitchell) thought that Mr. Dron was very much

* *Trans. Inst. M. E.*, 1899, vol. xviii, pages 194 and 331.
† *Ibid.*, vol. xvii. page 319.

nearer the mark in the estimates which he had given. Certainly while Mr. Dron's estimates showed that the coal-supplies were far from being unlimited, they contradicted to a great extent statements which had been recently made. Perhaps the only point in the paper which was open to serious criticism was that in which Mr. Dron dealt with the proportions of coal worked in the different counties. He took the proportions for the last twenty-four years and applied them to the total quantity of coal worked during five hundred years. This basis, he thought, while probably the only basis on which he could make estimates, was but a wild guess at the best. He would like Mr. Dron to say whether the proportion of the first five of the twenty-four years was not different from the total proportions of the twenty-four years taken together. The deductions taken by Mr. Dron from these figures showing the proportions to work, were interesting, and, although the figures themselves might not be altogether reliable, he thought that they might be regarded as generally true; such, for instance, as the figures mentioned in the last paragraph of the paper where Mr. Dron said:— "We must look especially to Ayrshire and Edinburghshire for future increases of output"* He (Mr. Mitchell) knew that there was a possibility of discovering a large coal-field in Dumfriesshire, but he did not know that the coal-field might extend, as Mr Dron said, to 80 square miles. He thought this field was worthy of investigation. Mr. Dron had apparently made an omission in his paper, with reference to this coal-field, as he did not state in any of the tables or elsewhere what quantity he included in his estimates for it. He was glad to notice the position that Mr. Dron had taken up in connection with exports. Although this was more of a commercial question than a matter affecting the management and working of coal-mines, it was a point which had been referred to in Mr. J. A. Longden's address. Mr. Longden proposed that an export duty of 6d. per ton should be put on coal, but he (Mr. Mitchell) thought Mr. Dron was right and Mr. Longden wrong. The carrying-industry of the country owed much of its prosperity to coal-exports and this industry was of such immense importance to the country that he thought it would be a serious mistake to hamper the export of coal in any way. They should rather seek to increase the value of their coal-resources, by practising economy in the consumption of coal, and also by endeavouring to develop the water-power of the country as suggested by Mr. Dron. This water-power would

* *Trans. Inst., M.E.*, vol. xviii, page 211.

prove valuable in the future, although it was easy to over-value it at present as a competitor with cheap coal. He thought that Mr. Dron was right in including in his estimates coal down to 1 foot in thickness. They knew of many cases in which seams were being worked at present down to 18 inches at a comparatively moderate cost. There were coal-seams in the North of England about 18 inches thick, which were wrought at a surprisingly low rate. Everything depended on the special conditions under which the seams were worked. In conclusion, he thought that Mr. Dron's paper was a valuable contribution to the *Transactions* and one of the most important that the members had had for some time.

Mr. WM. SMITH (Ayr) thought that an estimate nearer to the actual quantity still to be worked than that shown on Table I. with regard to the Dalmellington district would have been formed if Mr. Dron had kept the two districts separate, namely, that north of Dalmellington, and that of Dalmellington and Patna. At the Dalmellington end of the coal-field, there were the whole of the Upper Coal-measures from the Palacecraig ironstone down to the Blackband ironstone with all the intervening beds of coal. Most of the upper seams were already worked out, the lower seams now being worked. A bore-hole fully 1,200 feet in depth in the south-western corner of the coal-field passed through the Limestone-measures and found the coal-seams of that series burnt and useless. So far as was known at present, only the Upper Coal-measures could be relied on. In the Patna district, where the Limestone-measures cropped out, and where the Patna thick coal-seams were worked, 30 per cent. of this coal-field must be deducted for whin-dykes and burnt coal. About 1 mile to the north-east of Patna, the Upper Coal-measures appeared, bringing in the Blackband ironstone and the coal-seams immediately above it; but large interbedded sheets of whin also occurred and rendered those coal-seams useless; so that in the Dalmellington district there were only the Upper Coal-measures to count on, and in the Patna district, the Lower or Limestone-measures.

The further discussion was adjourned.

Mr. WILLIAM SMITH read the following paper on "Hauling and Pumping Underground by an Oil-engine":—

HAULING AND PUMPING UNDERGROUND BY AN OIL-ENGINE.

By WILLIAM SMITH.

It is now a number of years since the oil-engine as a source of power underground was first brought before the notice of colliery owners and managers. As a motor, it cannot be said to have been generally adopted in mines, therefore the description of a plant hauling 150 tons of coal per day, and pumping 45 gallons of water per minute against a head of 130 feet, may be of interest to the members.

Jellieston colliery, where the plant to be described is at work, belongs to the Dalmellington Iron Company, Limited. The pit is 678 feet deep, and the coals worked are the Patna thick seams, the working of which on the threefold longwall system, was described to the Institute some years ago* by Mr. David Smith, the general mining manager of the company.

The coal to the rise of the field having become exhausted, and a small portion to the dip being still to work, it was decided to erect an oil-engine plant. The considerations which led to the adoption of this form of power were (1) the steam-boilers at the colliery were already taxed to their utmost in keeping the pumping-engine and winding-engine going ; (2) there was no shaft-space available for steam-pipes or haulage-ropes ; and (3) the area of the coal to be worked was limited (Fig. 1, Plate XIX.).

The coal-field is very much broken up by faults and whin-dykes, large areas of the coal are burnt and useless, thus rendering very problematic any estimate of the quantity of coal to be worked. Water was known to exist in the coal to the dip, and it was felt desirable to have the prime power convenient to the pumps (Fig. 1, Plate XIX.).

A Priestman oil-engine with gear was erected to haul 150 tons per day of 8 hours, from a dook 780 feet in length and dipping at a gradient of 1 in 4½. The cylinder is 10½ inches in diameter, 12¾ inches stroke, and, at 183 revolutions per minute, 9 brake horsepower is given out.†

The drum is placed loose on the shaft ; it is 2 feet 9 inches in diameter, and is fitted with a claw-clutch to put it in and out of gear as

* *Trans. M. Inst. Scotland*, vol. xiv., page 113.
† *Trans. Inst. M.E.*, vol. iii., page 259.

required (Figs. 2, 3 and 4. Plate XIX.). When in gear and coming up with the full load the rope travels at a speed of 50 feet per minute; when out of gear, the empty tubs running down the dook unwind the rope with their own weight; and in this way, the motion of the engine is required in one direction only. A friction-clutch connects the engine to the gearing, so that with the engine at full speed no shock or jerk is transmitted at the lifting of the load.

On one end of the drum-shaft is a crank-disc, 3 feet in diameter, working a connecting-rod, 18 feet in length, attached to a rocking-lever; and from this lever a wire rope, 1¼ inches in diameter, is led to the pump placed near the bottom of the dook.

The pump has a bucket, 9 inches in diameter and 3 feet stroke, and runs at a speed of six strokes per minute. It is of the ordinary bucket-type, with the working-barrel lying at the gradient of the dook. The water is delivered during the upstroke, counter-balance weights taking back the bucket and rope. The pump is connected or disconnected from the engine at the rocking-lever, by means of a short chain, one end of this chain being fixed to a prop, and there is a hook on the other end. When the pump is to be disconnected, this hook is dropped into the links of another chain (which connects the pump-rope to the rocking-lever), just as the pump reaches the top of its stroke; on the back stroke, the short chain holds the pump-rope, thus allowing a muzzle-pin to be taken out at the rocking-lever. The time taken to put the pump on or off is only a few seconds.

The oil-engine is situated 480 feet from the pit-bottom and 90 feet from the dook-head. The exhaust-gases pass direct into the return-airway, which is immediately behind the engine-house (Fig. 1, Plate XIX.), and through which 20,000 cubic feet of air per minute are passing. By means of a regulator, a current of 3,000 cubic feet of air from the intake-airway is allowed to pass through the engine-house, keeping it cool and carrying away any disagreeable smell. When the combustion of gases inside the cylinder of the oil-engine is complete no fumes are seen coming from the exhaust-pipes; should, however, the internal parts of the engine be allowed to become dirty, then imperfect combustion is the result, and the gases have a strong and unpleasant smell, but they are not inflammable.

The oil-engine is fitted with a self-starting apparatus, consisting of an iron pipe ¾ inch in diameter, fitted with a cock; and this pipe conveys the oil and air direct from the tank to the vaporizer without passing them through the spray-maker. When the self-starter is about

to be used the vaporizer is made a little hotter than is necessary when it is not used, the flywheel is turned until the crank has just passed the inside centre, the brass ball on the eccentric rod is then in contact with the fork and the electric current is ready to explode the charge. The pressure in the oil-tank is raised 7 or 8 pounds above the regular working pressure, or to nearly 25 pounds per square inch, by vigorously working the hand-pump for a few seconds. The cock on the self-starter is then suddenly opened, and the engine starts immediately. The cock is thereupon sharply closed, and the oil and air sent in their proper channel through the spray-maker.

The governors regulate the speed of the oil-engine by apportioning the quantity of oil and air passing through the spray-maker.

The engine and gearing are bolted to pitchpine logs, 9 inches square; cement-concrete to a depth of 18 inches surrounds and fills the space between these logs, giving a very firm foundation, and one in which no vibration whatever is felt.

The engine-house is 18 feet long by 15 feet broad, inside the brickwork, with rails and sheet-iron to form the roof. No inflammable material is used in the construction of the engine-house, or the engine itself, with the exception of the pitchpine logs on which the engine rests, and the portions of these which come directly under the engine are covered with sheet-iron.

The following rules for the guidance of the enginemen, and approved by H.M. inspector of mines, are printed and hung in the engine-room:—

Special Rules for Petroleum-Engine.

Notice is hereby given that the following regulations shall be strictly observed in connection with the working of the petroleum-engine, namely:—

1.—The petroleum shall only be taken into the mine in a sealed tank, sufficiently strong to resist an ordinary fall of the roof or possible damage from any other cause.

2.—The storage or sealed tank shall be kept in a securely closed chamber, outside the engine-room, as also any paraffin oil that may be used for the lamps.

3.—The petroleum shall only be taken into the mine in quantity sufficient for one day's working of the engine.

4.—Safety-lamps alone shall be used while filling the tank of the engine with petroleum or when transferring the petroleum from one vessel to another.

5.—The tank of the engine shall be taken out of the mine, when it requires to be cleaned.

6.—Any waste of petroleum shall be at once covered or taken up with sand.

7.—All wood and inflammable material shall be removed from the engine-room.

8.—The waste-oil from the engine and refuse cotton-waste shall not be allowed to accumulate, but must be sent out of the mine daily.

9.—Such petroleum only shall be used to drive the engine as will not give off an inflammable vapour below 100 degrees of temperature on the Fahrenheit scale (Abel test).

The engine hauls 28 to 30 rakes per day with 9 hutches per rake; the average time taken to haul the loaded rake is 15 minutes, the empty tubs running down in 1 minute. The weight of the load drawn is:—9 hutches at 5 cwts. each, or 5,040 pounds; coals, 13 cwts. per hutch or 13,104 pounds; rope, 130 fathoms at 4 pounds per fathom or 520 pounds; and a total weight of 18,664 pounds.

The load due to gravity is 18,664 (18,664÷4·5 or) 4,147·55 pounds; adding for friction (144 pounds per ton on 8·3 tons or) 1,195·2 pounds, makes a total of 5,342·75 pounds; and this is equivalent to (5,342·75 × 780÷15 × 33,000 or) 8.41 horsepower. In the foregoing calculation, the writer has not taken into account the work expended in overcoming the friction of the gearing, so that if an allowance were made for this, the engine is fully developing 9 brake horsepower.

Ordinary Scotch shale- or paraffin-oil is used, and is taken into the pit at the commencement of each shift, in two strong 5 gallons vessels, fitted with screwed stoppers. The oil is emptied direct into the engine-tank and the vessels returned to the surface, so that no storage is required in the pit. The consumption of oil is 1·29 gallons per hour, or fully 1 pint per brake horsepower per hour. This quantity, for hauling and pumping included, gives a cost of 1·21d. per ton of coal drawn.

The weekly cost of working the oil-engine is as follows:—

	£	s.	d.
2 Enginemen, 13 shifts at 4s. 10d. per shift	3	2	10
3 lbs. of cotton-waste	0	0	7½
½ gallon of lubricating oil, at 2s. per gallon	0	1	0
156 gallons of oil for generating power in engine, at 7d. ...	4	11	0
Renewals of battery per week of 120 hours, ...	0	3	5
Upkeep and repairs, taken over 4 years	0	5	0
Total ...	£8	3	10½

On an average output of 900 tons per week, the cost is equal to 2·18d. per ton.

The price of the engine was £384, and, including erecting, making of engine-house, seat, brickwork, &c., was completed for £450.

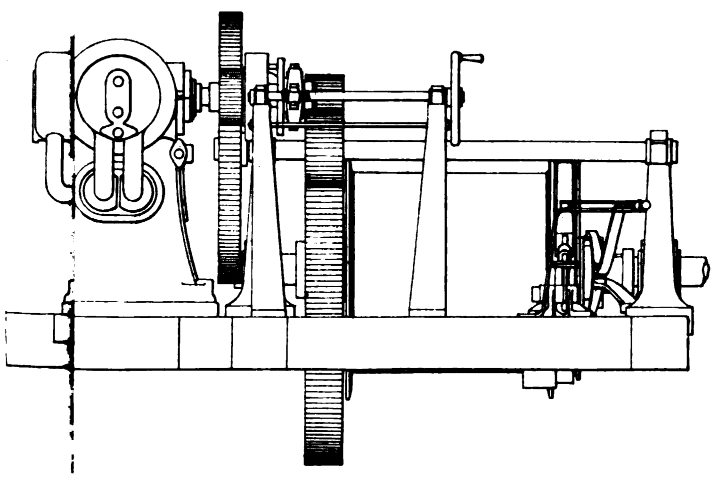
To keep the engine in good working order requires care and attention; it must be regularly cleaned, and dirt or soot must not be allowed to accumulate in the vaporizer or spray-maker. There are four points which may be said to require special attention in order to ensure the highest efficiency:—(1) The compression of the charge in

the cylinder must be effective, there must be no leakage from the exhaust or inlet-valves, or from defective piston-rings ; (2) the spark for igniting the charge must be kept at its full strength ; (3) the spray must be properly proportioned; and (4) there must be no leakage of air from the closed oil-tank.

The engine has done its work very efficiently, and has given very little trouble even under the varying load of pumping. It is advisable, however, to have certain of the parts in duplicate, so that in the event of any of them going wrong they can be replaced at once.

In placing the foregoing particulars before the members, the writer does not wish it to be understood that he considers an oil-engine plant at all times and in all circumstances preferable to the more simple steam-apparatus ; but rather to show that there are conditions in mining operations in which the oil-engine may give fair average results.

FIG. 3.-END ELEVATION.



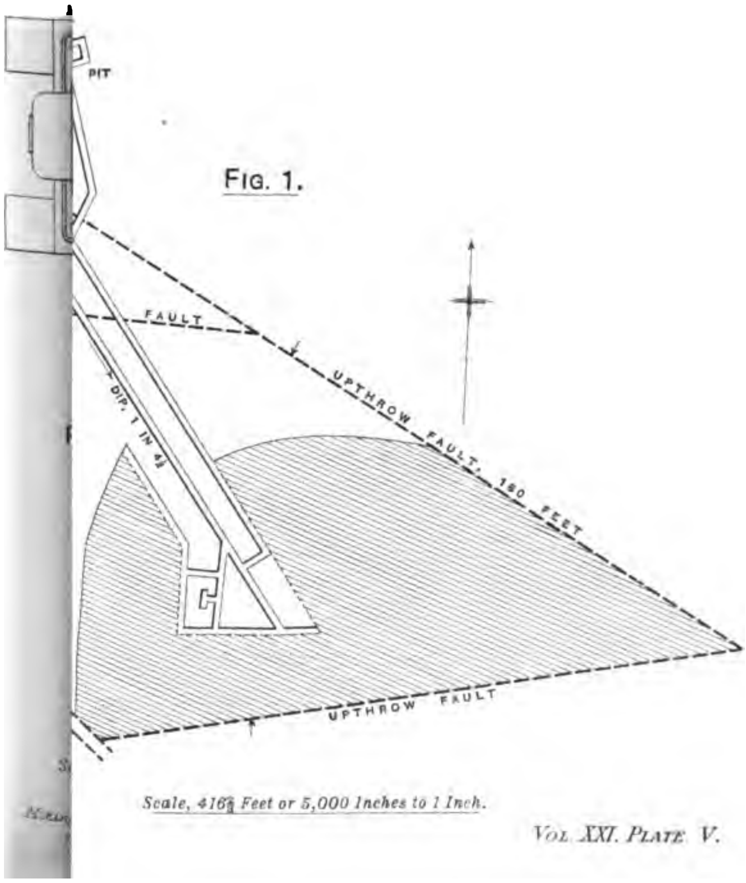


FIG. 1.

Scale, 416⅔ Feet or 5,000 Inches to 1 Inch.

MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT THE ROYAL VICTORIA STATION HOTEL, SHEFFIELD, FEBRUARY 24TH, 1900.

MR. W. H. CHAMBERS, PRESIDENT, IN THE CHAIR.

The minutes of the previous General Meeting were read and confirmed.

The following gentlemen were elected, having been previously nominated:—

MEMBER—

Mr. GEORGE FARMER, Colliery Manager, 3 Strafforth Terrace, Denaby Main, Rotherham.

ASSOCIATE—

Mr. THOS. BATT, Oulton, Leeds.

Prof. W. RIPPER read the following paper on "A Power-indicator for Steam-engines":—

A POWER-INDICATOR FOR STEAM-ENGINES.

By W. RIPPER.

The writer was led to design this power-indicator, owing to the difficulties of indicating high-speed engines with the ordinary indicator. In the early days, he thought that, if he could separate the motor-steam that was always driving the piston into one chamber, and the exhaust-steam that was always resisting the motion of the piston into another chamber, he could by means of thermometers placed in each chamber, read the mean temperature of the steam passing through the cylinder. Afterwards, he could obtain the corresponding mean pressure of the steam from tables, and subtracting one from the other, he would obtain a constant record of the mean effective pressure of the steam in the cylinder of the engine

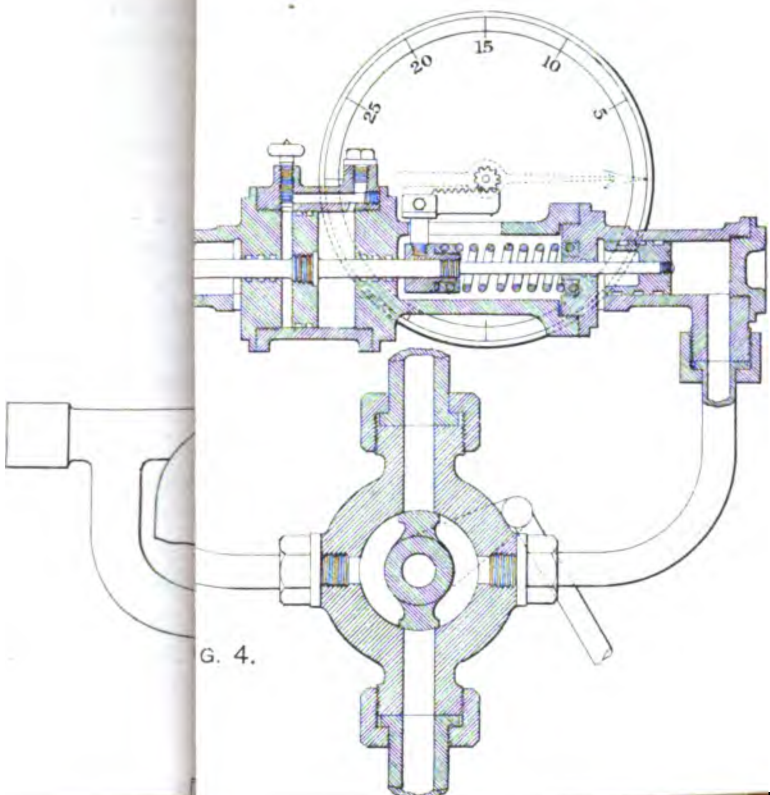
Figs. 1 and 2 (Plate XX.) shew the instrument adopted for ascertaining the temperature of the steam. The thermometer was placed inside the brass tube, A, and was surrounded with oil. He found that the pressure obtained from the recorded mean temperature of the steam was always below the actual mean pressure, as shown in Fig. 3 (Plate XX.).

He thought at first that an accurate record of the mean pressure of the steam could not be ascertained by means of a pressure-gauge, but on trial, he found that he was able to measure the true pressure by means of a gauge, without resorting to the thermometer-arrangement. Another instrument that he had devised was illustrated in Fig. 4 (Plate XX.); in which the mean effective pressure of the steam is recorded by the pointer.

As the instrument did not record sufficiently accurate results, he changed the design, and the final form of the instrument is shown in Fig. 5 (Plate XX.). Altogether he had tried seven different types of the instrument. He considered that the instrument shown in Fig. 5 was the best, because it was an automatic instrument. The two gauges recorded steadily the pressures of the driving or motor-steam, and of the resisting or exhaust-steam.

He had had much trouble in order to obtain perfect gauges, and found that they worked most efficiently in an inverted position. In order to obtain a steady reading of the mean pressure acting upon a gauge, the author employs two throttling-taps, one (A) close to the instru-

icator for Steam-Engines."



G. 4.

ment, and the other (B) close to the gauge; and by the use of these regulating taps, the oscillations of the pointer of the gauge may be reduced to the requisite degree of steadiness, without interfering with the accuracy of the reading of the steam-pressure. There was a rough adjustment by one tap, and a fine adjustment by the tap near the gauge.

He had made experiments to ascertain the amount of throttling requisite in order to ensure a steady mean reading of the pressure-gauge when subject to variations of pressure. He attached the pressure-gauge to the cylinder by means of a syphon-pipe, and found that the mean effective pressure was recorded when he could maintain the water in the syphon. After lengthy trials, he found at length that he could keep the water in the syphon by throttling it at each end, and he had experienced no difficulty since that discovery. The pressure-gauge when so adjusted gave constant readings, and the pointer was steady, so long as the load was steady.

The ordinary indicator only gave a "snap-shot" of the power of the engine at the particular stroke at which that diagram was taken. It was important for many purposes that the engineer should know not only what happened at one moment but whether the pressure changed from moment to moment; and his improved gauge showed all the changes that were taking place every moment in the cylinder, in compound engines, triples, or four cylinders combined.

It was well known that very often the power of a compound engine was not equally distributed between the various cylinders:—thus the low-pressure cylinder might be doing twice as much work as the high-pressure cylinder. The engineman might find that a pin became hot, but it would not occur to him that one cylinder was doing more work than the other. This gauge would show the power developed by each cylinder, and whether the power was distributed as it should be between the cylinders.

In an electric-station plant it was needful to know exactly what work was being developed. If two engines were working at half load, and one could do the work at full load, it would be more economical to work one engine only. If the pressure-gauge were marked so as to show the load for which an engine was best fitted, the engineer on going to the engine-house would know whether the engine was working at the most efficient load or not.

The President (Mr. W. H. Chambers) remarked that the instrument described by Prof. Ripper would facilitate registering of the duty

of engines of which so many engineers had charge. Mining-engineers had not the time to devote to taking indicator-diagrams, but by the Ripper indicator, they could see what work was produced at any moment.

Mr. G. BLAKE WALKER moved that a vote of thanks be given to Prof. Ripper for his interesting paper.

Mr. H. B. NASH, in seconding the motion, said he had no doubt that mining-engineers would gladly adopt the instrument.

DISCUSSION ON W. H. CHAMBERS' "NOTES ON GOB-FIRES." *

Mr. H. E. GREGORY (Cortonwood Colliery) remarked that so far as the Barnsley bed in South Yorkshire was concerned, it would be worked at considerable depths in the future, leading to enhanced difficulties of working, one of which would be increased liability to gob-fires. The President had referred to the fires at Tawd Vale colliery, Skelmersdale, in 1870 to 1873, which was at that time in his charge. The fire was treated very differently from the fires which the President had described. The fires occurred in the Great Skelmersdale Seven-feet coal-seam, underlain by a bed of fire-clay or spavin, 10 to 15 feet thick, and the roof consisted of a dark gray freestone 50 to 60 feet thick, and of such a nature that it was most difficult to get a fall. The seam had an upper coal from 3 to 4 feet thick, and below, but not separated by a parting, was a coal of better quality and 4½ feet thick; there was next a thin bed of fire-clay, and the bottom coal was 2 to 3 feet thick. The seam was liable to spontaneous combustion, and the amount of pyrites in it was so great that in some cases the pick would not touch it. The coal was of a most inflammable nature; if 300 tons were laid down, it had to be taken up quickly or it would take fire. The fire, as he found it, was enclosed in an area of 30 to 40 Cheshire acres. The seam was worked on the post system, and the origin of the fire was unknown. The previous manager drove a road, so as to approach the fire and quench it with water; but, as soon as the fire was reached, it spread very rapidly, and the workmen were driven out of the pit, which was then closed. After he took charge of the colliery, various attempts were made to extinguish the fire by filling it out, and owing to the dry nature of the seam, the fire spread most rapidly. After he had been a short time at the colliery, he formed the opinion that the only way to keep the fire within bounds was to

* *Trans. Inst., M.E.*, vol. xviii., page 154.

build a wall and prevent access of air. A road was driven, and on the side next to the fire, a brick wall, 9 inches thick, was erected as a temporary shield until a stone wall could be built. There was a strong rock in the workings and in the goaf, which was worked like a quarry, and the stone used in building the wall. The wall was built solid with rock laid in mortar, and from 7 to 9 feet thick. In front of the rock wall, a brick wall was built from floor to roof, and made absolutely tight. The brick wall kept the air off the inner wall and the fire. The work of enclosing the fire was successfully carried out, and without loss of life. The walls kept the fire under control, and they had no further trouble with it. Some lives were lost at a fire caused by the ignition of timber in an intake air-way. It was supposed that a boy had entered an engine-house made of wood, and by some means set it on fire, which spread to the timbering. The workmen, when they came out-bye, found the timbering on fire, and came to the conclusion that the enclosed fire had broken out again, and 4 men lost their lives. Another fire started in another district of the pit, but it was enclosed before it got beyond control, and he never had any difficulty with it. He had had to deal with other fires, which he had dealt with in the manner described by the President, but each fire required the adoption of the most suitable plan for its extinction.

Mr. M. H. Habershon said that in South Staffordshire fires had originated at places where timber had been built into the pack-walls. If that was found to be the experience of other districts, it would be desirable to discontinue the custom of building timber into pack-walls at the corners of cross-gate roads and other places in longwall workings.

Mr. Thos. Stubbs (Rotherham Main Colliery) said that he had had experience of gob-fires in Leicestershire. At his first gob-fire he was told that the best plan was to fill out the fire, and he stood with the workmen until some of them were overcome by the fumes. Eventually they had to abandon the removal system, and both the return and the intake airways were closed for a time, and afterwards re-opened. The coal-seam being wrought was 6 feet thick, with a roof of fire-clay from 3 to 4 feet thick. As time went on, the main gate-roads and cross-gate roads were driven at intervals of 300 feet, the fire-clay was taken down, and all the original roads buried, and by this system the whole of the goaf was hermetically sealed, and there was no further trouble. He found that the best system was to seal off the goaf by burying the original gateways practically on a level with the tops of the pack-walls, and after this was achieved no more fires occurred.

The PRESIDENT (Mr. W. H. Chambers) replying to the discussion, said he was glad that his paper had elicited from Mr. Gregory a very interesting account of the fire at Tawd Vale collieries. He was by no means an advocate of tackling fires in all circumstances in the same way as those dealt with in his paper. Other fires of which he had had experience had been dealt with in different ways. In the case of a fire in 1868, at Tinsley Park colliery (of which he had early experience), it was impossible to approach the seat of the fire. The shafts were partially filled up, water was poured on the débris, and the shafts were closed for two years. When the colliery was re-opened, the district containing the fire was sealed by walling, and new workings were opened out in the virgin coal. Recently, the old workings had been examined after many years, and the fire was found to be extinguished. He had seen gob-fires in the Leicestershire and Warwickshire districts effectually extinguished by the system known as "wax walling":—a pack-wall was built and covered with clay, a workman went round constantly with a bucket of water to keep it damp, in that way all access of air was excluded, and the fire died out. There was a difference in the nature of the coals which altered the methods of extinguishing fires; thus one coal if put in a fire-grate would burn to the last cinder, while another coal required constant stirring to keep it burning.

He might add that wherever timber was left in pack-walls, it allowed the air to percolate through the open space, and a fire was certain to ensue. Timber packs used to be built at the corners of the gateways, but it was found that they broke the roof, which stood better without them. He found that where a gateway had been abandoned and timber packs were left, that there was not sufficient ventilation to carry off the generated heat, and although the goaf might be an old one, a fire always ensued where timber had been left. No timber was now left behind in longwall workings where it could possibly be removed; the face of the workings was taken as long and in as straight a line as possible, the whole of the coal was removed, the goaf fell solid behind the timber, and that was the most effectual way of obviating underground fires. There could be no heat in a goaf from which the air was absolutely excluded. He approved of the system described by Mr. Stubbs in which the ripping was taken down and the pack-walls were completely buried within 100 feet of the coal-face.

The further discussion was adjourned.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE, APRIL 28TH, 1900.

MR. THOMAS DOUGLAS, PAST-PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting and reported the proceedings of the Council at their meetings on March 31st and that day.

The following gentlemen were elected, having been previously nominated :—

MEMBERS—

Mr. GEORGE MARRIOTT BARBER, Mining and Metallurgical Engineer, Soemalata, Celebes, Dutch East Indies.

Mr. JOHN CHARLES BINKS, Colliery Manager, Norchard Colliery, Lydney, Gloucestershire.

Mr. WALLACE BROAD, Geologist, Mineral Surveyor and Mining Engineer, P.O. Box 283, Bulawayo, Rhodesia, South Africa.

Mr. WILLIAM HENRY CLARK, Mining Engineer, 108, Cantonment, Kampthee, Central Provinces, India.

Mr. KONRAD ERNST RICHARD ENGEL, Bergmeister, Linden-Allee, 67, Essen (Ruhr), Germany.

Mr. EDWIN RICHARD FIELD, Mining Engineer, 11, Ironmonger Lane, London, E.C.

Mr. HENRY GORE, Civil and Mining Engineer, Superintendent and Consulting Engineer to the Victorian Gold Estates, Limited, 395, Collins Street, Melbourne, Victoria, Australia.

Mr. F. GRAHAM, Colliery Manager, West Hunwick Colliery, Hunwick R.S.O., Co. Durham.

Mr. PABLO HAEHNER, Mining Engineer, Bilbao, Spain.

Mr. ROBERT STUART HILTON, Colliery Manager, Thorn Lea, St. Ann's, St. Helen's, Lancashire.

Mr. PETER KIRKEGAARD, General Superintendent, Canadian Goldfields, Limited, Deloro, Hastings County, Ontario, Canada.

Mr. JAMES MALCOLM MACLAREN, Surveyor, Coromandel, New Zealand.

Mr. STEPHEN ROBERTS, Mining Engineer and Manager, Penlan, Trefriw, R.S.O., North Wales.

Mr. William Sutton, Mechanical Engineer, Baltic House, Balham Hill, London, S.W.

Mr. Sidney Bristow Wright, Chemist and Metallurgist, Canadian Goldfields, Limited, Deloro, Hastings County, Ontario, Canada.

Associates—

Mr. Joseph George Herriotts, Deputy-overman, 15, Gladstone Terrace, Binchester, Co. Durham.

Mr. Albert J. Jeffery, Colliery Official, 6, Bowlby Street, Houghton-le-Spring, R.S.O., Co. Durham.

Student—

Mr. William Charles Mitchell-Withers, Mining Student, School of Mines, Camborne, Cornwall.

DISCUSSION OF MR. J. EMERSON DOWSON'S PAPER ON "METRIC WEIGHTS AND MEASURES."*

Mr. J. H. Merivale said that engineers who had had practical acquaintance with the use of the metric system seemed to be strongly in favour of it. In his own experience as a colliery-apprentice in Belgium, he found that the metric system facilitated the ordinary work which a colliery-apprentice had to perform. It had been objected that the metric system was not adopted in the United States of North America and in Russia. Although strictly speaking it was true that the metric system was not used in America, yet they had a decimal monetary system, and therefore the Americans could not be said to take the view of the matter generally accepted in Great Britain. No doubt, to make the change now would strike British engineers as appalling, and whether it was possible to do so he could not say, but if it could be done, mining-engineers would find metric weights and measures a very great convenience.

Mr. T. E. Forster said that engineers who were interested in this subject would find both sides of the question very ably treated by Dr. Sellers in *Cassier's Magazine*.† That gentleman had used both systems in two separate engineering works.

Dr. Coleman Sellers (Philadelphia, U.S.A.) wrote that the paper appearing in *Cassier's Magazine* passed through the press while he was absent in Switzerland, and was misleading, inasmuch as it seemed to be a recent expression of his opinion, when in point of fact it was a copy of a paper read many years ago which the editor of the magazine thought it would be interesting to have reproduced. The editor had used part of

* *Trans. Inst., M.E.*, 1899, vol. xvii., page 326.

† 1900, vol. xvii., page 365.

a letter written to him on the subject as a prelude, with no indication of the fact that the paper was not a new production. His (Dr. Seller's) effort had been to uphold the legality of the use of the metric system, but not to force it upon the country to the exclusion of existing metrology. As science advanced any unit convenient for a new line of work was readily adopted, but its adoption need not be used as an argument against what was good in the system that had prevailed for so many years and had become fixed by usage.

Mr. W. Taylor Heslop's paper on "The Coal-fields of Natal," was read as follows :—

THE COAL-FIELDS OF NATAL.

By WM. TAYLOR HESLOP, Dundee, Natal.

Geology.

Although the coal-fields of Natal have already been described in the *Transactions*, the developments of recent years have been so great that the writer feels no apology is necessary for again bringing the subject before the members.

Compared with the other coal-fields of South Africa, the Natal coal-field attracts especial interest; it is the only one that presents any special geological or mining difficulties; and it produces the best quality of coal of any of the developed fields of South Africa.

The Coal-measures of South Africa are usually considered to belong to the Triassic formation, but their precise geological horizon can by no means be regarded as definitely determined.

In correlating the sedimentary formations of South Africa with those of Europe, the great difficulty is the extreme paucity of fossil remains in the South African measures. In the Coal-measures, there have been discovered the following fossils:—*Glossopteris* at Vereeniging and Middelburg, in the Transvaal; and impressions of this fern are comparatively common in Natal. *Calamites* has been observed by Mr. A. R. Sawyer at Grootvlei, near Heidelberg, in the Transvaal, and also in Natal. *Sigillaria* has been found at Vereeniging and in the Middelburg district of the Transvaal. *Vertebraria* has been found at Hammanskraal, near Pretoria, and also at Vereeniging. *Noeggerathiopsis Hislopi* was discovered in a sandstone underlying the coal at Vereeniging. Certain undetermined fucoids have also been found in the Natal Coal-measures.

From the occurrence of these distinctive Carboniferous fossils, it might readily be assumed that the South African Coal-measures, like their European equivalents, belonged to the true Carboniferous series. Unfortunately for this hypothesis, in the Stormberg district of Cape Colony, reptilian fossils (of undoubted Triassic age) occur in the Beaufort Beds immediately underneath the Coal-measures. To explain such contradictory evidence two main hypotheses have been put forward, namely:—

(*a*) That all South African Coal-measures belong to the Triassic

epoch, and that the Carboniferous fossils found in them are survivals from Carboniferous times, which are probably peculiar to the Southern Hemisphere. In support of this theory it may be remarked that in other parts of the Southern Hemisphere there is evidence of such survivals, of which the marsupials and certain varieties of *Lingula*, in Australia, are the most prominent examples. With the exception of *Glossopteris*, which is also found plentifully in the Triassic coal-deposits of India, fossil impressions are very rare in all South African Coal-measures. Of course such an hypothesis seems to undermine the fundamental basis of geological classification, and in consequence is not readily accepted.

(*b*) The other hypothesis is that the Stormberg coal-beds of Cape Colony are of Triassic age (the evidence of the underlying reptilia being indisputable); but the other coal-deposits, namely, Vereeniging and Middelburg in the Transvaal, and Natal, are Carboniferous or Permo-Carboniferous, and thus there have been two distinct periods of coal-deposition in South Africa. Mr. Dunn, late Government Geologist of Cape Colony, has been the principal exponent of this theory. He found at Vereeniging the coal directly overlying the Dwyka Conglomerate (hereinafter referred to), whereas in the Stormberg Beds, the coal is underlain by—(1) the Beaufort Beds, and (2) below them, the Ecca Beds. Hence he contends that there is a great probability of a large coal-field existing, at a considerable depth, and over a large area of Cape Colony and the Orange Free State; a coal-field having its horizon immediately above or in the Dwyka Conglomerate (much older than the Stormberg coal-seams), and separated from it by the Beaufort Beds and Ecca Beds. So far, however, the prospecting that has been done has failed to prove the existence of these assumed coal-deposits.

In Natal, the Beaufort Beds, the Ecca Beds, and the Dwyka Conglomerate are found in regular sequence underlying the Coal-measures, although no reptilian fossils have as yet been discovered in them. From these facts, it may be concluded that the Natal and Cape Colony Coal-measures occupy the same geological horizon, and there can be little doubt that the Natal and the Transvaal coal-deposits likewise belong to the same period: although in the Transvaal the Ecca and Beaufort Beds are non-existent, and the Coal-measures rest directly on either the Dwyka Conglomerate or older measures.

With so many disputed points in the way of a proper geological classification, the only satisfactory course was to adopt a separate classification altogether for South Africa, which, as laid down by the State Geologist of the Transvaal, Dr. Molengraaff, is as follows :—

(1) Upper Karoo Beds.

(2) Lower Karoo Beds :—

(a) Molteno Beds—Coal-measures.

(b) Beaufort Beds—Shales and sandstones, with reptilia.

(c) Ecca Beds—Hard blue shales.

(d) Dwyka Conglomerate—A glacial deposit, with blue shaly matrix.

(3) Table Mountain Series :—

(a) Gatsrand Sandstones—Coarse sandstone and grits.

(b) Dolomites—Dolomitic limestone overlying the Black Reef.

(c) Witwatersrand Beds—Quartzites, slates and gold-bearing conglomerates.

(4) Barberton Series :—

Quartzites, slates and schists containing the gold-bearing fissure-veins of Barberton, Zululand, Murchison Range, Lydenburg, and Rhodesia.

In Cape Colony, the Coal-measures are found overlying the Beaufort Beds; at Vereeniging they lie directly upon the Dwyka Conglomerate; and in the Brakpan, and parts of the Middelburg district they also overlie a conglomerate, which is probably of Dwyka age, although different in character from what is generally associated with the Dwyka Conglomerate, the matrix being a coarse sandstone instead of a fine hard blue shale ; but the enclosed pebbles and boulders are the same, namely, quartz, quartzite, slate, and granite, from the older formations. At Cypherfontein, south of Krugersdorp, the coal lies directly upon the dolomite ; and at Boksburg it rests upon the Witwatersrand formation (the Main Reef Series passing directly under the workings of the Wishaw colliery).

South African coal is generally considered to be a subaqueous and lacustrine deposit. The late Prof. Green found in some of Cape Colony coal, under microscopic examination, a distinct concretionary structure, and the writer has observed the same peculiarity in coal from the Brakpan district of the Transvaal, where, after weathering, the concretionary layers of carbonaceous matter readily peeled off.

South African coals may be divided into three classes, as distinguished by the appearance of the coal alone :—

(a) Bright coal, similar in appearance to British bituminous coal, showing a cubic cleavage, but with more distinct horizontal lamination than British coal.

(*b*) Dull coal, similar to splint coal, with cubic or irregular cleavages, but often with a coarse grain, and always with a much higher proportion of ash than the bright coal, with which it is immediately associated. It is not confined to any particular horizon in the seam. More generally it is found in the upper portion, but it is often interspersed in layers throughout the seam, and may change in position and thickness within a very short distance.

(*c*) Semi-bright coal, a fine grained coal with a conchoidal fracture, and no lamination. In appearance it resembles some of the Welsh or Irish anthracites, but with a graphitic lustre. It contains from 25 to 35 per cent. of ash, and the upper and unworked portion of the Clydesdale (Transvaal) coal-seams forms a good example.

The dull coal and bright coal are often found interlaminated, the one gradually merging into the other. In all the bright coal, narrow bands, from $\frac{1}{32}$ to $\frac{1}{4}$ inch in thickness, of dull coal occur. The conclusion as to the origin of the coal, drawn from the writer's observations, is that the bright coal, like its European equivalent, grew as vegetable matter, and was deposited *in situ*; while the dull coal, on the other hand, was transported by water in the form of decaying vegetable matter, and during such transportation was subject to disintegrating influences, losing a portion of its volatile constituents, and acquiring a portion of the muddy impurities from the flooded waters which brought it to its present position. In confirmation of this theory it may be observed that the dull coal invariably contains less volatile matter than the bright coal, (which would be covered up by superincumbent matter before any great quantity of its volatile constituents could be disseminated by natural decay); while the dull coal, in course of transportation and consequent abrasion and division into finer particles, would lose more of its volatile matter. Again, transportation by flooded waters would naturally result in the incorporation of muddy impurities in the drift-formed coal, and we find that the dull coal always contains a larger proportion of ash than the bright coal with which it is immediately associated. The streaks of dull coal in the bright coal would be accounted for by the periodic flooding of the Carboniferous swamps, in which the coal had its origin; and such periodic floods are always much more violent in tropical than in temperate climates.

It is a further noteworthy feature of the South African coal-fields that where the seams are abnormally thick there is a greater proportion of dull and impure coal, and the seams are less constant in character and continuity than the seams of medium thickness. Thus the seams of

Natal, which are comparatively thin, contain much less dull or impure coal, and are more uniform in thickness and character than those of the Transvaal, which are found to be of greater thickness, but very variable in character. At Boksburg, there is seldom more than 6 inches of bright coal in a total thickness of 12 feet. In the Springs district, there is about 6 feet of bright coal in a total thickness of 30 to 60 feet. At Middelburg, it is seldom that half the thickness of the seam consists of bright coal; whilst in Natal there is rarely more than 6 inches of dull coal in the seam.

The Coal-Field.

The Natal coal-field occupies the northern portion of the colony, forming a triangle of which the base is a line drawn east and west across the colony, about 12 miles north of Ladysmith; and the two sides are, roughly speaking, the boundaries of the colony to the north of that line (Fig. 1, Plate XXI.). The average elevation above the sea is about 4,000 feet, although near Langs Nek coal is found almost 5,000 feet above sea-level (Fig. 2, Plate XXII.). The gross area of the coal-field is about 1,800 square miles, but only a fraction of that area contains workable coal.

From a careful comparison of the accompanying sections (Fig. 5, Plate XXII.), it will be seen that there are only two workable sections, of from 2½ to 9 feet, and averaging from 4 to 6 feet in thickness. These two workable sections are made up of four different seams, and owing to considerable variations in the thickness of the intervening strata, the working sections at the different mines are made up of one, two or three of these component seams of coal.

The seams have been found at all depths up to 500 feet, but most of the existing mines are working at depths of less than 300 feet. The deepest shaft, at present, is that of the Durban Collieries Syndicate at Dannhauser, which is 500 feet deep. It is probable that workable coal may be found at a greater depth on the western portion of the coal-fields, but up to the present it remains unproved. The strata underlying the main seam of coal have been bored to a further depth of over 400 feet at the South African collieries; 500 feet at the New Campbell collieries; and 562 feet at Kleinfontein, south of Elandslaagte, without proving any more workable coal.

Throughout the entire coal-field, the seams lie very nearly level, being subject only to local undulations, rarely exceeding an inclination of 1 in 30 from the horizontal, and there is a very slight general dip, not

exceeding 1 in 200, in a south-westerly direction. Displacements of the measures by ordinary faulting are very rare, and the seams of coal are more constant in quality and thickness than are those of any other coal-field in South Africa, although by no means as constant as British coal-seams; and to commence mining without careful preliminary boring and testing of bore-holes is only to court disaster.

Enormous outbursts of intrusive igneous rock (dolerite or whinstone) form the most important feature of the coal-fields, either from a geological or mining standpoint. The whole of the northern district of Natal is intersected by great vertical dykes of dolerite, which have overflowed (both as cappings and as intrusive sheets) over very large areas of the country. On the property of the New Campbell collieries, a dyke has been proved which probably exceeds 1,200 feet in thickness. On the property of the South African collieries, a horizontal intrusive sheet has been proved by bore-holes and shafts, in thickness from 132 to 157 feet; in length, extending from Dundee to Glencoe, for a distance of 6 miles; and in an area not less than 18 square miles. Not a single working colliery can lay claim to be free from disturbance by these intrusive dykes and sheets. Denudation has removed the softer Coal-measure sandstones and shales, and left standing the harder dolerite, and in consequence nearly every hill or *kopje* carries a capping of dolerite-boulders.

To digress for a moment, it may be pointed out that in the present war the Boers have almost invariably taken up positions on kopjes covered with these dolerite-boulders, which form an admirable cover, and constitute their favourite fighting-ground.

That the horizontal dolerite-sheets are intrusive in character, and not merely surface-deposits or submarine deposits contemporaneous with the deposition of the Coal measures, is proved by observations made by the writer at the South African collieries. There the sandstones at the point of contact with the dolerite-sheet, both above and below it, have been fused into a hard quartzite by the heat from the igneous rock. It is further proved by the occurrence of the horizontal sheets at varying horizons relative to the coal-seams, and there can be no doubt that the period of so extensive a plutonic eruption was subsequent to that of the deposition of the Coal-measures.

The effect of this plutonic activity on the coal has been to alter all of it in immediate proximity into an anthracite, or semi-anthracite —by the heat from the molten igneous rock driving off a portion of the volatile matter from the coal. No definite rule can be laid down to determine the distance from a dyke or sheet, over which the coal is

affected by it. But roughly speaking, the coal is found unaffected at a distance from the dyke, equal to the thickness of the dyke. At the first shaft of the South African collieries, coal 86 feet distant from a horizontal sheet of dolerite 153 feet in thickness was found to contain 8·6 per cent. of volatile matter, compared with 18 per cent. at the adjoining mine; that is, it may be inferred that 9·4 per cent. of the volatile matter had been driven off. At the New Campbell colliery, an enormous dyke, 1,200 feet or more in width, was struck at about 100 feet from the shaft. At the shaft, the coal was found to contain only 4 per cent. of volatile matter. In a pair of main drifts, at right angles to the dyke, the coal gradually increased in volatile matter as the distance from the dyke increased. At 1,200 feet from the dyke, a test made by the writer gave 15 per cent. of volatile matter. At 1,400 feet from the dyke (the present working-face), another test gave 19 per cent. of volatile matter: the coal showed indications of a coking character, and that the verge of the affected area had been reached, the coal having gradually changed in nature from anthracite to bituminous. Under favourable conditions of draught and furnace, and when fired lightly and frequently, and with only sufficient stirring to remove ash and clinker, coal with from 10 to 15 per cent. of volatile matter will give fairly good results for steam purposes; but for general use, and when placed in the hands of Kaffir and coolie firemen, who are accustomed only to bituminous coal, it is not found suitable, and a coal with less than 15 per cent. of volatile matter will not find a ready market for steam or household use. There is at present a very small demand for anthracitic coal for malting purposes. The opening up of the Transvaal, by the removal of the duty upon coal, may cause a demand for limited quantities of anthracite for metallurgical purposes, in place of coke. For the supply of the present markets, therefore, anthracitic coal is of no value, and we can only reckon on the bituminous areas.

The occurrence of the dolerite-intrusions is so extensive, and their influence is so widespread, that probably more than half of the Natal coal-field has been affected in this way. Indeed, in certain large areas that have been examined in detail by the writer, nearly three-fourths of the coal was found to be affected by igneous action.

Reference to the sections, No. 1 to No. 4 (Fig. 5, Plate XXII.) shows that the seams to the south of the Biggarsberg range are much thinner than those to the north of it, and the experience of several ventures has proved that notwithstanding the advantage of lower railway-

rates (with the exception of Elandslaagte colliery), the coal south of the Biggarsberg is unable to compete with that to the north. Estimates of the workable areas of coal under present conditions can only include the districts from Glencoe to Newcastle, or about 560 square miles, out of a total area of 1,800 square miles. From that, also, large deductions must be made:—For the areas of coal affected by igneous action; for areas from which the coal has been denuded; and for areas of inferior coal, which would leave about 150 square miles of workable and saleable coal under present conditions. With an allowance of 25 per cent. for waste, including abandoned pillars and unsaleable dross, there is left a total of about 764,000,000 tons of available coal.

The annual output of coal in Natal during the last ten years has been as follows:—

Year.		Tons.	Year.		Tons.
1889	...	25,609	1894	...	141,010
1890	...	81,547	1895	...	160,115
1891	..	87,774	1896	...	216,106
1892	...	142,160	1897	...	243,960
1893	...	129,925	1898	...	387,811

During the month of September, 1899, the last full month's working before the commencement of the war, the output from the different mines was as follows:—

Names of Collieries.	Tons.	Names of Collieries.	Tons.
Dundee ...	14,502	East Lennoxton	503
Natal Navigation	9,298	West Lennoxton	317
Elandslaagte...	6,343	New Campbell	12
St. George's ...	6,138		
Natal Marine	2,163	Total ...	40,351
Newcastle ...	1,075		

Of this amount, 19,407 tons were sold for bunkering trade at Durban, and 508 tons were exported. In its production, 128 Europeans, 1,672 natives, and 878 Indians were employed.

WORKING COLLIERIES.

(1) *The Dundee Collieries.*—These collieries have always, and still occupy the leading position among the producing mines. Coal has been worked there during the last 30 years, although not to any great extent until some 10 years ago, when the output reached 4,000 tons per month; and it was not until two years ago that it had to meet competition from other collieries to any considerable extent. With an easily-worked seam, 4 feet thick at from 40 to 80 feet in depth, it presents no mining difficulties. Coal has been worked from six different shafts, three of

which are being worked. The coal is worked on the bord-and-pillar system, by natives and coolies under European supervision. The natives are paid from £1 to £2 5s. per month, and provided with food and housing. The coolies are brought by the Colonial Government from India, under a five years' indenture, at a wage of about 12s. 6d. per month with food and lodging. A Jeffrey electric coal-cutting plant will shortly be installed at the mine. The coal produced has the following average analysis :—

	Per cent.
Volatile matter	16·63
Fixed carbon	70·53
Sulphur	4·18
Ash	8·66

Although higher in sulphur and ash than some of the competing coals, the larger proportion of fixed carbon enables it to hold its own.

The coal is prepared over fixed screens.

(2) *The Natal Navigation Collieries.*—The collieries are situated about 4 miles from the Natal Government Railway, with which they are connected by means of a branch-line. The coal is reached by two rectangular shafts, 200 feet in depth. Coal is hoisted from one shaft in single-decked cages (carrying 2 trucks side by side), running in pitch-pine guides. The winding-engine has two horizontal cylinders, each of 17½ inches by 36 inches, fitted with piston-valves, and working an 8 feet drum.

The screening-plant is very elaborate and complete. From a pair of side-tipplers the coal passes on to jigging-screens, where the small coal is separated. The large coal passes on to a long plate-belt, fitted with a middle-trough for refuse. Owing to the shale-bands in the seam (No. 8, Fig. 5, Plate XXII.), there is much refuse to be picked out, and a small army of coolie-women and children are employed on the belts. From the end of the belt, the coal passes either down a plain shoot into the trucks, or down a bagging-shoot when required. The refuse is carried from the trough down a back-shoot on to a transverse belt, carrying it away to the trucks, which take it by an endless rope on to the dump. The small coal falls into hoppers, from which it is raised by a pair of elevators to revolving cylindrical screens, which separate it into nuts, peas and dross. The nuts from both screens pass on to a central picking-belt, which delivers either into railway-trucks for nut-coal, or on to deflecting side-shoots, to mix with the large coal. The peas and dross fall into hoppers, from which they can be transferred either into trucks or on to transverse belts, one of which conveys the coal direct

to the fire-holes of the boilers, and the other to the trucks which take the refuse to the dump. The screening-plant and winding-engine were erected from plans prepared by Mr. T. Grant Colquhoun, late consulting engineer to the company.

Ventilation is secured by a Capell fan, 10 feet in diameter by 5 feet wide, and steam-power for the whole of the machinery is supplied from three Cornish multitubular boilers and one Lancashire boiler. There are large workshops, well equipped with tools, including lathe, drilling, shearing and screwing-machines, and saw-bench. The mine is also well provided with workmen's quarters, cottages, coolie and Kaffir compounds, offices and stores.

The coal is worked on the bord-and-pillar method. In the initial stages, the pillars were left small, so as to secure more rapid development, but they are now being left sufficiently large to allow of their removal at a later stage. The coal makes sufficient gas to necessitate the use of safety-lamps. As the unsophisticated Kaffir will, without compunction, stick his pick through the top of a Marsaut gauze in order to make his lamp burn better, the responsibility of supervision is no sinecure.

Analyses of the seam of coal now being worked are as follows :—

	No. 1. Per cent.	No. 2. Per cent.
Volatile matter	9·69	15·17
Fixed carbon	80·37	71·59
Sulphur	1·72	1·30
Ash	7·70	11·41
Water	0·52	0·53

The coal for these analyses was taken at the point where the shaft struck the coal, close to a dolerite-dyke, by which the coal was undoubtedly affected ; and so far as the volatile matter and fixed carbon are concerned, these analyses are altogether unreliable as an index of the quality of the coal produced, for the coal undoubtedly contains at least 25 per cent. of volatile matter. For raising steam, it gives results quite equal to, or, if anything, superior to Dundee ; and, containing less sulphur, it makes less clinker. Unfortunately it is very friable, and will not stand handling without breakage. The permanent plant has only been working about 2 years.

(3) *The St. George's Colliery.*—The St. George's Coal and Estate Company holds ground both east and west of the Natal Navigation colliery. Exploration was commenced in the first instance on the eastern side, but the coal, although of excellent quality, was too much disturbed by dykes, and was rather too close to the outcrop ; and work-

ing was abandoned. Operations were next commenced on the western side, where coal was struck at a depth of 310 feet in two rectangular shafts. The main shaft is fitted with double-truck cages, running in wire-rope guides. The winding-engine is a small geared engine, which will shortly be replaced by a direct-acting engine.

The screening-plant consists of 2 plate picking-belts, which receive the coal from jigging-screens. The small coal from the screens is elevated to 2 cylindrical screens, where the dross is separated, and the nuts pass on to a short picking-belt. Between the large coal-belts is another belt, travelling in the opposite direction, carrying away the refuse to the hoppers. There is also a bagging-platform and shoots for bagging coal when required.

Steam is supplied by 2 Lancashire boilers, 30 feet long by 7 feet in diameter. Ventilation is secured by a Schiele fan, 10 feet in diameter.

The coal is worked on the bord-and-pillar system, the pillars being left too small to admit of their removal. The coal makes some gas, safety-lamps are used throughout the mine, and no explosives whatever are allowed. A year ago an explosion occurred through a native opening his lamp, which resulted in the death of 5 natives; the explosion was so violent that the flames reached 40 feet above the shaft-mouth, continued burning for a considerable time, and ignited the shaft-timbering. This explosion, and other reasons, have hampered the development of the mine, and it only reached the profit-earning stage a month or two before the commencement of the war. In quality, the coal is almost the same as the Natal Navigation coal, but it is not so friable, and is equal to any produced in South Africa.

(4) *The Elandslaagte Collieries.*—These, the only productive collieries situated south of the Biggarsberg, possess the advantage of being nearest to the market, which compensates for the thinness of their seams, and the slightly inferior nature of their coal. The coal has been developed by means of three circular shafts, two of which are fitted up for drawing coal.

The main shaft is fitted up with jigging-screens and picking-belts. Both the seams of coal (No. 1, Fig. 5, Plate XXII.) are worked, but most of the coal is taken from the top seam. From a comparison with the Dundee seams, it appears that the top portion of the main seam at Dundee has approached, and here forms the bottom portion of the upper seam.

The coal is worked on the Welsh double-stall system, with satis-

factory results. A Jeffrey electric coal-heading machine has been in use for some time, and has given satisfaction. As native employees must be paid and fed whether working or not, and cannot always be obtained on short notice, a coal-cutting machine is of great advantage in coping with a sudden extra demand for coal.

(5) *The Natal Marine Collieries.*—The pits are situated about 2 miles east of Dundee, and are the most recent producers in the colony. They have proved, by extensive boring, an area of about 1,000 acres of coal, similar in section and quality to that of the Dundee collieries, and lying for the most part very near to the surface. The coal area is cut up by a number of dolerite-dykes, and for these reasons a central screening-plant has been erected, which will be supplied with coal from several shallow shafts in different parts of the property. Up to the present date three shafts have been sunk to the coal, none of which exceed 40 feet in depth. These shafts are fitted with single cages, worked with small geared winding-engines and semi-portable boilers. The coal is raised to the surface, and conveyed by endless-rope haulage to the elevator of the screening-plant.

The screening-plant consists of 2 jigging-screens, hung by wooden-lath suspenders, and delivering on to 60 feet bar-belts with $\frac{3}{4}$ inch spaces. The belts have jib-ends, which can be depressed to deliver directly into the trucks or raised to deliver on to the bagging-shoots. They are fitted with scrapers to convey the coal, which falls through the bars in cleaning, back to the cylindrical screens placed directly under the jiggers, where the small coal is classified into nuts, peas and dross or duff. The nut-coal falls into 20 tons hoppers, from which it is discharged into trucks on the same line of railway as the large coal. The peas fall into hoppers, from which they can be discharged into trucks, or taken in small trucks either to the boilers or with the dross to the dump. The plant is as good as any at present erected in Natal.

The coal is worked on the bord-and-pillar system. It is easily worked, but on account of a bad roof requires considerable timbering. Although it had only been in the market a few months when the war commenced, the coal had already acquired a very good name and ready sale.

(6) *The New Campbell Collieries.*—As already stated, the main shaft was unfortunately located within 100 feet of an enormous dolerite-dyke; and, where the coal was struck, it only contained 4 per cent. of volatile

matter. As this coal was found unsaleable, the work underground has been restricted to development-drives, at right angles to the dyke, to open up the bituminous areas away from the dyke. After 1,400 feet of driving, bituminous coal of very good quality had just been proved when work was suspended. The bituminous area had further been proved by several diamond-drill borings.

The surface-works include a tubular-steel headgear and a fixed screen, delivering the coal on to a Greening wire picking-belt.

(7) *The South African Collieries.*—These mines were promoted by the De Beers Mines, Limited, with the idea of ultimately supplying coal to the Kimberley market. In sinking the shafts, a horizontal sheet of dolerite, or whinstone, 153 feet in thickness, was penetrated. The rock was so extraordinarily hard that progress was very slow. In the middle and lower portions of the sheet contraction-fissures divided the dolerite into long, irregular, vertical, hexagonal columns. The slight occasional deviation from the perpendicular of these columns caused some of them to be undermined by the shaft sinking, and serious accidents occurred in consequence. In one fall that came within the immediate experience of the writer, a column 40 feet long slipped down behind the timbering, broke off the hanging-bolts, and dragged down a quantity of timbering. Fortunately, the workmen had been already withdrawn, and no loss of life ensued. Coal was struck at a depth of 360 feet, or 86 feet below the bed of dolerite, and gave the following analysis :—

	Per cent.
Volatile matter	8·6
Fixed carbon	79·7
*Ash	9·7
Water	2·0

* The percentage of sulphur in the ash was 3·35.

Boiler tests, though variable in results, were not sufficiently satisfactory to justify further work at that point, and it will probably be found necessary to sink fresh shafts on one of the bituminous areas within the property, which covers about 16,000 acres.

A very complete plant has been procured, comprising a 70 feet lattice-steel headgear, with guide-ropes for cages to carry 2 trucks end to end ; jigging-screens, with a bar-belt fitted with jib-ends for the large coal and a plate-belt for the nut coal, on to which the coal is delivered by a side-shoot from the screen. The winding-engine has 2 cylinders, each 16 inches in diameter, geared to a drum 10 feet in diameter, and

supplied with steam from a Lancashire boiler, 30 feet long by 7 feet in diameter; it is the only portion of the permanent plant at present erected.

(8) *Newcastle District.*—In the Newcastle district, the Newcastle, East Lennoxtown and West Lennoxtown collieries are producing coal in a small way, and with small plants. The Crown collieries and No. 42 colliery are both opening out, but have not yet reached the producing stage. The coal in this district contains about 30 per cent. of volatile matter. Some of it is very good indeed, but it is more variable in quality and in thickness than the Dundee district.

Between the Natal Navigation colliery and the town of Newcastle coal of very good quality and thickness has been proved at a depth of 500 feet at Dannhauser, in a shaft sunk by the Durban Collieries Syndicate. The coal has been analysed as follows:—

	Top Coal-seam.	Bottom Coal-seam.
	Ft. Ins.	Ft. Ins.
Coal	3 10	4 2
Shale	...	0 2
Coal	...	1 3
	Per cent.	Per cent.
Volatile matter ...	40·00	31·20
Fixed carbon ...	49·78	57·56
Ash	9·42	10·44
Moisture	0·80	0·80

The amount of sulphur is not stated in the above analyses, but it is not excessive.

An analysis of coal taken from the Caernarvon ground between Dannhauser and the St. George's colliery possesses interest, as showing perhaps the lowest results in ash and sulphur yet recorded in Natal for a seam of workable thickness:—

	Per cent.
Volatile matter	23·20
Fixed carbon	67·00
Ash	7·50
Sulphur	0·95
Moisture	1·35

At the Dudley colliery, on the eastern border of the coal-field, a fine seam of coal 6 feet thick is slightly affected by igneous action.

South of the Biggarsberg, the Wallsend colliery, Natal collieries (Waschbank), Natal Steam-coal colliery, and Ramsey's colliery (Wessels

Nek), and Wessels Nek collieries, most of them developed by adit-levels, have all ceased working, owing to the thinness of the seams, or inferior coal, making competition with the other mines very difficult.

In the neighbourhood of Rorke's Drift, and the eastern end of the Biggarsberg, the country is almost one mass of dolerite, and it is unlikely to contain coal of any value.

On the western boundary of Natal, the coal probably exists at great depths, as the ground rises towards the Drakensberg mountains until it is cut off by the Great Drakensberg fault, but the igneous disturbances are great and extensive. On the other side of this fault, which marks the watershed of South Africa, coal is not found in the Orange River Colony borders, although at Langs Nek tunnel, and in the neighbourhood of Charlestown, coal of inferior quality has been found at an elevation of nearly 1,400 feet above that of the Natal coal-seams generally.

In the district of Estcourt, as shown in Fig. 2 (Plate XXII.), there is a detached patch of Coal-measures, but the coal at no place exceeds a few inches in thickness, and it evidently represents only the lower portion of the Coal-measure series, and the upper portion containing the workable coal-seams has been denuded away.

To the east of Dundee, on both sides of the Buffalo river, magnetite of exceptional quality has been found. Analyses made for the writer showed over 72 per cent. of metallic iron, but up to the present time no development-work has been done.

Markets and Outside Competition.

Up to the present date, the bunkering trade of Durban furnishes the largest market for the coal-output, and of the last full month's output (September, 1899) of 40,351 tons, 19,407 tons were sold for bunker coal. The next largest consumers are the Natal Government Railways. The railway-facilities for the transport of coal are good: the coal-rate is 0·45d. per ton per mile, or 9s. per ton for the distance of 240 miles from Dundee to Durban. Since February, 1899, a special reduction has been made, with the view of encouraging the export trade. This consists of a rebate of 33 per cent. on the ordinary rate for all coal exported from the Colony.

The loading-facilities at Durban Harbour are meagre. At present, all the coal is loaded into ships in baskets or bags on the backs of Kaffirs,

and costs about 1s. 6d. per ton for loading and trimming. Improved loading-facilities will be necessary before any great expansion of the export-trade can take place.

The only two districts that are worthy of consideration as possible competitors with Natal in existing markets are Vryheid in the Transvaal, and St. Lucia's Bay in Zululand. The Vryheid district contains detached outliers of coal very similar in quality to the Dundee coal; and a railway is being built from Dundee to the town of Vryheid, but the cost of the extra 40 or 50 miles of railway-transport will probably prevent it from competing in the Durban coal-market.

The St. Lucia's Bay coal-field is very extensive, and contains several seams of coal, one of them being 45 feet thick, but variable in character. Three samples, taken by the Commissioner of Mines, from selected parts of this seam, gave the following analyses:—

	No. 1.	No. 2.	No. 3.
	Ft. Ins.	Ft. Ins.	Ft. Ins.
Coal	2 4	2 5	1 5
	Per cent.	Per cent.	Per cent.
Volatile matter ...	10·9	11·2	10·2
Fixed carbon ...	80·0	75·8	75·5
Ash	6·1	12·2	13·0
Moisture	3·0	0·8	1·3

Tests of this coal on the locomotives of the Natal Government Railways were distinctly unfavourable. It was stated that the coal was high in sulphur, which was not determined in the above analyses. So far as proved, the coal is anthracite, and unless bituminous areas can be found, it is hardly likely to enter into serious competition with Natal coal.

Detached portions of Coal-measures, forming a continuation of this coal-field, are found on different parts of the Natal coast, some indeed quite close to Durban; but borings have never exposed more than a few inches of coal, the thicker seams having probably been denuded away.

At present, railway-communication from Durban in the direction of St. Lucia's Bay extends no further than the Zululand border, but a concession has been granted for the construction of a railway to the coal-fields there. St. Lucia's Bay might also form a shipping-outlet for the St. Lucia's Bay coal-field, but a considerable amount of dredging would be necessary to open up that magnificent natural harbour.

Reference to the statistics of production already quoted shows that out of a total output of 40,351 tons in September, 1899, only 508 tons were exported from the Colony. It is from the export-trade, which is only just beginning, that any considerable expansion of the Natal coal-

industry must come. These 508 tons were exported to the following places :—Cape Colony, 252 tons 16 cwts.; Beira, 129 tons 17 cwts.; and Chinde, 125 tons 7 cwts.

It is to the Cape Colony markets that Natal coal-owners are now turning their attention, in the hope of capturing the demand at present supplied by Welsh coal. It is estimated that the requirements of the Cape Colony amounts to 500,000 tons per annum, which have hitherto been supplied by Welsh coal, by collieries in the Stormberg and Indwe districts of Cape Colony, and from Vereeniging on the Vaal river.

The locomotive superintendent of the Cape Government Railways has made tests of the various fuels, and the results were given by him in evidence before a Government Commission on railway coal, in October, 1899, as follows :

Place of Origin.	Name of Colliery.	Weight of Coal giving equal effect.
Welsh	Ocean Merthyr	1·00
Cape Colony	Stormberg District, Cape	1·75
,, ,, ...	,, ,, Contato	1·50
,, ,, ...	,, ,, Cyphergat ...	2·00
,, ,, ...	,, ,, Fairview	2·00
,, ,, ...	,, ,, Indwe	1·80
,, ,, ...	,, ,, Molteno, Vices' ...	2·00
,, ,, ...	,, ,, ,, Woolfs'	2·00
,, ,, ...	,, ,, Penshaw	1·60
,, ,, ...	,, ,, Wallsend	2·00
Orange River Colony ..	Vereeniging	1·60
Natal	Dundee, Navigation	1·25
United States of America	Virginia, Pocahontas	1·20

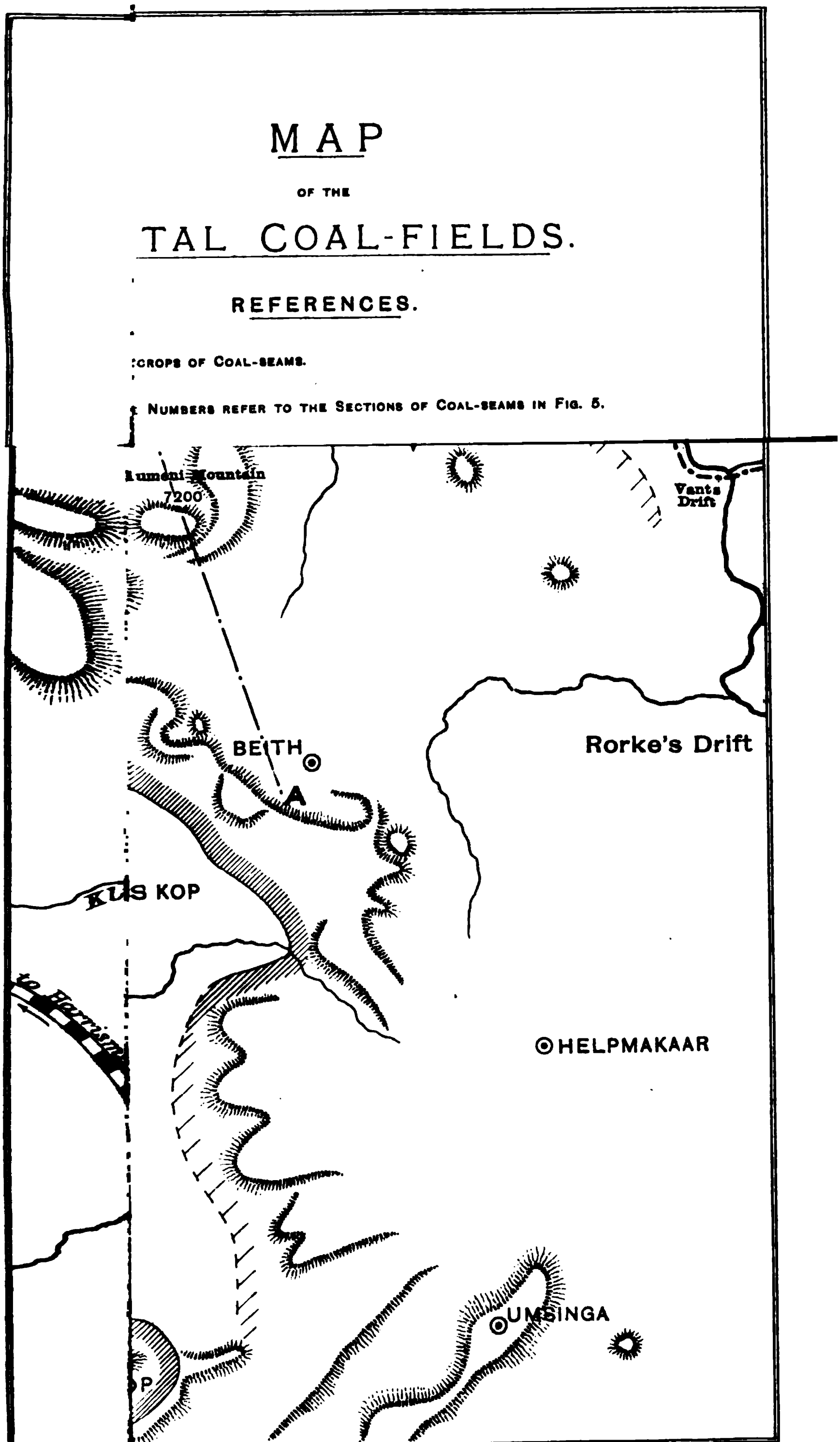
Special tests made on locomotives from Capetown to Touws river and back again, under similar conditions as to train-loads, etc., gave the following results :—

Coal used.	Coal burnt per train-mile. Pounds.	Evaporation of water per pound of coal. Pounds.
Welsh	30·04	not stated
Indwe	63·37	5·04 to 5·31
Natal Navigation ...	33·10	8·48

In evidence before the same Commission, Mr. C. Hitchins, director of the Dundee Coal Company, stated that Dundee coal could be sold in Port Elizabeth at 28s. per ton (2,240 pounds) against 38s. 3d. per ton for Welsh coal; and at Capetown for 25s. 6d. per ton, against 33s. 2d. per ton for Welsh coal.

A comparison of the above statements shows that Natal may confidently look forward to doing a considerable export-trade with the Cape Colony, by displacing Welsh coal. The building of the projected Harri-

The Institu... Tr... fields of Natal." Vol. XVIII, Plate XXI



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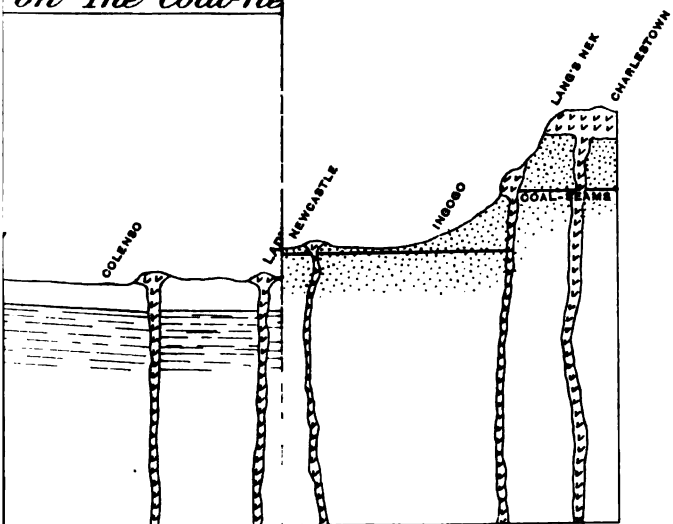

THE NATAL GOVERN

smith-Bloemfontein-Kimberley railway will undoubtedly ensure further large exports to Cape Colony, by displacing the Vereeniging coal now used in the Kimberley and De Aar districts.

The largest market for coal in South Africa is that of the Witwatersrand gold-fields. Hitherto Natal coal has been shut out from the Transvaal by a prohibitive duty of 5s. per 100 pounds. When the duty is removed, Natal coal must be prepared to pay a railway-freightage of from 4s. to 5s. per ton over and above that paid by the Middelburg coal. This difference would be largely caused by the 2s. 10d. per ton average freight from the Dundee district to the Transvaal border, and it would not be materially affected by any future re-adjustment of railway rates in the Transvaal. Whether Natal coal would be able, on account of its better quality, to carry this additional rate and compete in the Witwatersrand market with the Middelburg coal must be left for future trials to decide. Comparative tests in steamers indicate that Natal coal would be able to compete with Middelburg on the terms named, but any relative inferiority is always accentuated in steamer-trials as compared with stationary boiler-trials, where no forcing of the fires is required.

In conclusion, the writer begs to express his thanks for much valuable information supplied by Mr. Howard Harris, mining-engineer ; Mr. A. Crosby, manager of the Campbell colliery ; and Mr. James Cumming, honorary secretary of the Natal Mining Association.

Mr. JOHN M. LIDDELL (Stocksfield) wrote that he had visited most of the districts in South Africa in which coal had been discovered, and he had paid considerable attention to some of them, including that of Natal. He had read Mr. Heslop's paper with much interest, and he endorsed his observations and opinions entirely, so far as his experience extended.

He might remark that the scarcity of fossil remains had always been a matter of regret. He suggested that the European Carboniferous flora and fauna may have developed in the northern hemisphere originally, and have migrated slowly through later geological formations, some of them reaching the Triassic formation of the southern hemisphere.

Respecting a second and deeper-lying coal-field, extending through parts of Cape Colony and the Orange River Colony, he inclined to the opinion that the whole mass of Carboniferous and other beds, which are

of more recent date than the granitic and Silurian formations of the Cape Peninsula, King Williamstown, Lobombo, and of most of the "Low Veldt," is too thin to contain coal-seams of appreciable value, other than the coal-fields now known. The said strata appear to thin out, shales, coal-seams and sandstones alike, to the westward, through the western half of the Orange River Colony and Griqualand West, having thinner detached areas as about Beaufort West. Upon this point he thought that the De Beers Company may have interesting evidence, as some thin coal-seams occur near the surface at the Kimberley mine, and there was at one time much curiosity to discover whether pieces of rounded sandstone found in the body of the Kimberley mine had come up from a deeper Carboniferous system lying below. The Carboniferous strata of Stormberg, Natal, Orange River Colony and the Transvaal appear to form one continuous field, thickening individually to the north-east until they reach their limit on the "High Veldt" about Middelburg and Ermelo. It may be of interest to mention that the area of heavier rainfall coincides and increases in the said direction at the present day. There is, of course, a very large area in the western and north-western districts of Cape Colony too difficult of access for it to have been much explored.

He had seen strong evidence of sub-aqueous deposition of floating masses of vegetation, but he was of opinion that many of the dull seams, or portions of seams, had been formed by growth *in situ*, with frequent and varying deposits of mud and slime.

He thought that the occurrence of whinstone was perhaps the most notable feature of the whole coal-field, and that Mr. Heslop's paper gave a fair description of it. It occurs over the whole of the South African coal-field, and in fact is more or less peculiar to those portions of the country, which contain coal, gold, diamonds, or other products of mining interest. The whinstone usually contains sufficient iron to produce the rusty colour which is so common in the soil of the country, and it has been mistaken by the Boers for ironstone of commercial value. Its effect on the coal-seams is shown in the difference between the highly bituminous coal of Cyphergat and the semi-anthracitic coal of Indwe. Its effect on the working of mines was most notable in the "hard-rock" of Kimberley. He thought that the anthracitic seams were worthy of a good deal more attention, as there was a possibility of finding a seam of definite value as an auxiliary naval coal. At Indwe, the seam, or seams, are shown to be of reliable character, and from Indwe to Dundee there is a wide stretch of country within possible distance of the coast, in which seams are known to exist, and which, he thought, would have

been closely explored, and perhaps exploited, but for political hindrances.

Labour is one of the chief difficulties of African mining. The Kaffir miner has been indispensable in the past, though of a character which would be considered legally unsafe in Great Britain. He has no natural knowledge of tools or of civilized life, and his periods of labour are so limited and so intermittent that there is no probability of his acquiring safe habits or permanent profitable skill. It has often been said that white men cannot labour and live in such a climate, but the writer's experience of many years is to the contrary. He thought that the white labourer, if fairly established, would prove cheaper in cost per ton or per yard, and certainly more satisfactory. The difficulties hitherto had been largely the cost of immigration, of housing, of civilized food, of uncertainty of new exploitations, and especially of the degradation of white labourers by working on an equality with blacks. He thought that the establishment of an all-white staff of employees at some reliable mine was a desirable experiment, and would prove of capital importance to the industry.

Mr. T. Grant Colquhoun wrote that Mr. Heslop's paper contained a good general view of the geology of the coal-seams in South Africa and the Natal coal-seams in particular. He agreed with him that the best coal in South Africa, so far, was found in the Dundee district, north of the Biggarsberg range.

Mr. R. A. S. Redmayne (Seaton Delaval) said that Mr. Heslop's paper was a welcome contribution towards the further elucidation of the geology of Natal. Having spent nearly two years in surveying and development work in the Natal coal-fields, it gave him pleasure to state his agreement with nearly all Mr. Heslop's statements. Mr. Heslop stated that *Sigillaria* had been found at Vereeniging and in the Middelburg district of the Transvaal, but so far as he was aware, no such remains had been discovered in the Natal Coal-measures. This was of interest, owing to the fact that there could be little doubt that the deposits were of contemporaneous origin. Possibly, on further exploitation of the Natal Coal-measures, these might be discovered. One specimen of *Lepidodendron* was found near Newcastle (Natal), but no *Stigmaria*. The most characteristic fossil in these measures is *Glossopteris*, which is notably a Triassic fossil.

When in Natal, he hazarded a classification of the Natal rocks which he endeavoured to correlate with Prof. Green's division of the Cape

Colony system.* He regretted that Mr. Heslop had not laid stress on a great want felt by all those interested in the mining welfare of Natal, namely, the want of a systematic topographical and geological survey. The lack of the former had, as recent events had shown, cost this country dear, while as to the latter there existed only a few papers contributed by private individuals to scientific societies. It seemed incredible that a Colony which had been a British possession for 58 years, and which until 6 or 7 years ago was a Crown Colony, should not have had a proper topographical survey made of it. The benefit resulting from such a survey would far exceed the cost of making it—in fact it amounted to a necessity.

Mr. Heslop did not treat of the labour difficulty in the Natal coal-mines. Probably this subject would, in the near future, be of still more moment than it was even at present. Undoubtedly the development of the coal-deposits would be still further carried out when the war was concluded, and the trade of the Colony was enhanced by the abolition of heavy duties (enforced by the Transvaal Government) and increase of population and consequent development of the over-sea and land carrying trade. Owing to the uncertainty in the supply of native labour and the difficulties attending the training and supervision of the same, the safest and cheapest manner of working the collieries would be either entirely by coal-cutting machines with white labour; or, if deemed advisable to combine agricultural development with coal-production, as in all probability would be the case when the surface of a large property is owned by the company working the coal; Indian coolies of the right cast and kind could be introduced, who are adepts at agriculture—most of the vegetable and dairy trade of Durban was conducted by Indians—and these would pay for their holdings under the company with a proportion of their produce—mealies, vegetables, fruit, etc., their holdings being worked by their families and by themselves during their leisure, when not engaged underground.

The CHAIRMAN (Mr. T. Douglas) moved a vote of thanks to Mr. Heslop for his interesting paper, and trusted that the war would soon be ended.

The resolution was cordially approved.

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* *Trans. Inst. M.E.*, 1892, vol. iv., page 559.

THE BALMER PIT-PROP.

The Balmer prop consists of two cast-iron cylinders, one of which, A, is arranged to slide telescopically inside the other, B (Figs. 1 and 2). The lower cylinder, B, is packed with small coal so as to support the upper cylinder or ram, A, at any desired height. A head-tree, C, is placed, as usual, between the roof of the seam and the top of the prop. As the roof creeps down, the coal-packing, D, is compressed and yields slightly, allowing the props in use to support the roof evenly. As the roof gradually lowers further, the props may be eased by withdrawing some of the coal-packing, D, through one of the holes, E (preferably the hole nearest to the lower end of the ram, A). The prop can be readily withdrawn by easing the ram still further in the same way.

At Elswick colliery, on January 24th, 1900, a prop was set with a wooden head and sole-trees, 2 feet by 7½ inches wide, by 7½ inches thick: it stood 53 days, and being eased from time to time came down 6 inches by March 19th, when it was drawn in 1½ minutes in the presence of the overman and a deputy-overman of the colliery. It was re-set in the same place, and by April 5th it had lowered 3½ inches more, making 9½ inches in all since the first setting. The sole-tree, however, was split into halves, and after a new one had been fixed, the prop was still working, and could be lowered another 12 inches if necessary. The prop could be eased in 5 seconds.

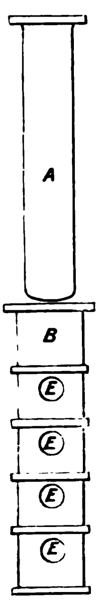


Fig. 1.

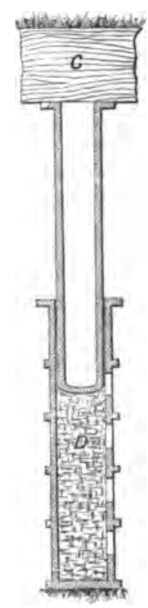


Fig. 2.

The following advantages are claimed for this prop:—(1) The props will last for many years, as they are practically indestructible and may be used over and over again; (2) they are simple in working and are liked by the workmen; (3) they are unaffected by water or atmospheric conditions, which often cause wooden props to rot rapidly; (4) the props may be used as pillars, shores or struts in any position, and are also very advantageously used in connection with girders; and (5) during

the time that the roof lowers or the floor rises, say 12 inches, from 6 to 8 wooden props would have been set to replace buckled or broken timber, consequently a great saving of labour will follow the adoption of the Balmer prop.

Mr. H. LAWRENCE remarked that he would not like to go into a longwall-face and attempt to lower the prop by taking out the packing from the bottom of the tube.

The CHAIRMAN (Mr. T. Douglas) said that he had recently had an opportunity of examining some props used under the Hepplewhite system. The props were tapered at the bottom end for about 10 inches, and on the roof settling the tapered end "fuzzed" and prevented the buckling of the prop. Out of 250 props, which he had recently examined, after they had come out of a mine, there were only two props which had buckled. The remainder had the "fuzzy" ends cut off, and were used again in a thinner seam. It was very curious to notice how the "fuzzing" had allowed the prop to maintain a perpendicular position. At another colliery, the system was being tried experimentally side by side with square-ended props, and had shewn very considerable economy in favour of tapered props.

Prof. H. LOUIS said that tapered props might possibly prove of advantage in seams where the floor was tolerably hard.

THE LJUNGSTRÖM CRANKLESS ENGINE.

Fig. 1 shows the interior of the Ljungström crankless engine, after the removal of that part of the casing which (Fig. 2) is nearest to the belt-pulley. In this half of the casing is a long brass bearing, fitted concentrically, carrying the shaft, on one end of which shaft, outside the engine, the belt-pulley is fixed, and on the other end, inside the engine, a four-armed casting, B, is fixed. The belt-pulley and the casting, B, rotate with the shaft.

The casting, B, contains four radial cylinders (B_1, B_2, B_3 and B_4), each of which contains a cylindrical hollow piston, which is shewn separately at C (Fig. 1). Each of the hollow pistons contains a roller, D, which is shown separately at D_1.

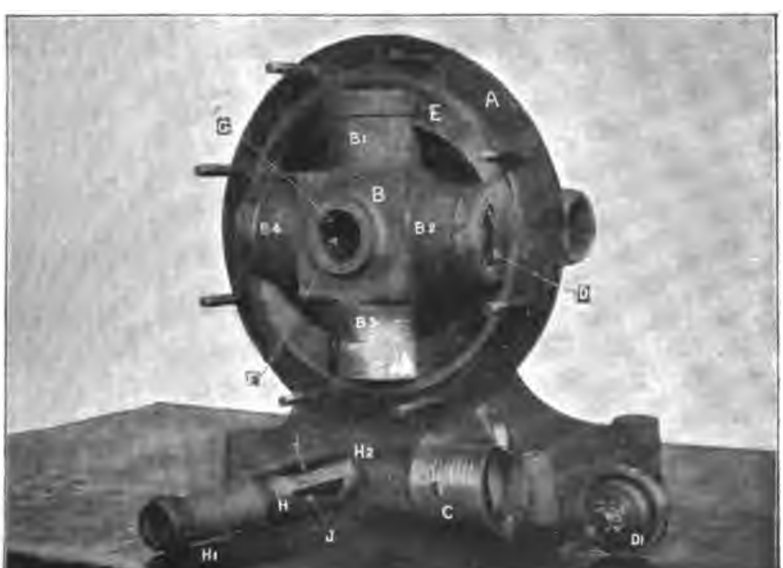


Fig. 1.—View of Ljungström Crankless Engine, with Casing Removed.

The roller, D (Fig. 1), as well as the rollers of the three other pistons, runs in contact with the elliptical track, E, placed in the casing, A, and fixed between the two halves of the cover when they are screwed together.

In the centre of the four armed casting, B, is a concentric and cylindrical hole, G, and at the bottom of each of the cylinders is a long slot, F, through which the cylinders communicate with the hole, G. A stationary and cylindrical balanced steam-valve, shown separately at H, (Fig. 1) is fitted into the hole, G. The stationary valve is screwed at the end, H_1, into the steam-supply pipe, which enters the engine at the centre of that half of the cover which has been removed, but which is shown in

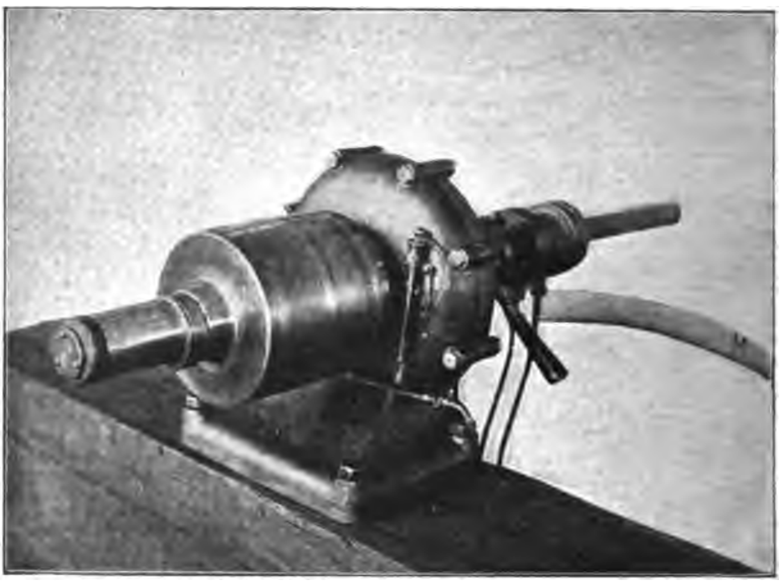


Fig. 2.—VIEW OF THE LJUNGSTRÖM CRANKLESS ENGINE.

Fig. 2. This valve has two long supply-ports, and similar exhaust-ports arranged symmetrically around the valve. One of the supply-ports is shewn at I, and one of the exhaust-ports at J (Fig. 1). The supply-port, I, communicates inside the valve with the steam-supply, H_1, and the exhaust-port, J, communicates inside the valve with the exhaust-end, H_2.

The four cylinders (B_1, B_2, B_3 and B_4) rotate together with the axle, to which they are connected by a screw-bolt connection. Centrifugal force, caused by this rotation, keeps the rollers, D, always in contact with the track, E, which, in consequence of its elliptical shape, causes the pistons to make two strokes during each revolution of the engine.

The valve being stationary and the cylinders (B_1, B_2, B_3 and B_4)

rotating round it, the slots in the bottom of the cylinders must necessarily pass over the supply and exhaust-ports of the valve, which therefore, although stationary, regulates the supply and exhaust.

The cylinders obtain their steam-supply from the supply-port of the valve, when the pistons move outward, and exhaust the steam through the exhaust-port of the valve, when the pistons move inward. The rotating force of the engine is consequently obtained from the side-thrust given by the pistons, when forced by the steam-pressure against the outward-going curves of the track.

The exhaust-steam passes from the cylinders through the ports, J, of the valve, to the end, H_2, and thence through the radial-slots in the coupling of the cylinder-casting and the main shaft into the casing, from which it escapes by the exhaust-pipe formed in the casing as shown in Fig. 1.

The cut-off of the steam in the cylinders depends upon the width of the inlet-slots, I, in the valve, but it can also be regulated by a slight alteration of the radial position of the ports. The handle for adjusting the valve is shown in Fig. 2.

If the valve be turned by moving this handle into an upward position, the inlet-slot, I, in the valve will come into such a position relatively to the track, E, that the steam will enter the cylinders when the pistons are moving inward instead of outward, thereby producing a strong back-pressure, which first stops the engine, without shock, and instantaneously sets it in motion in the opposite direction. The direction in which the engine rotates consequently depends upon the relative radial position of the inlet-opening, I, of the valve, in relation to the outward-going curves of the track, E.

By adjusting the handle, the speed of the engine is also regulated, but for ordinary purposes a governor rotating with the main shaft is attached by means of a rod going through the shaft of the engine to a throttle-valve inside the steam-inlet at the other side of the engine. In Fig. 2, the governor is placed inside the cylindrical cover extending from the centre of the belt-pulley, and the rod from the governor goes through the engine to the throttle-valve inside the casting at the opposite side, between the handle and the steam-supply pipe.

The rollers inside the hollow pistons, D (Fig. 1), rotate on roller-bearings, the axles of which are fixed at both ends into the pistons, as shown at C. Each piston has two guides, which keep it from twisting, and maintain parallelism between the track and the rollers. Two pistons are always moving simultaneously, and, these being of the same weight, the motor is perfectly balanced.

The bottoms of the radial cylinders are placed close to the cylindrical valve, and the cushioning-volume of steam for a 16 horsepower engine is less than 5 per cent. of the volume of the stroke.

A 16 horsepower engine measures about 13 inches by 14 inches, by 20 inches, and weighs less than 85 pounds. The cylinders are $2\frac{3}{4}$ inches in diameter and $\frac{13}{16}$ inch stroke. The experiments recorded in the following table were made by Prof. R. L. Weighton :—

No. of Experiment.	Cut-off.	Steam-Pressures per Square Inch at		Revolutions per Minute.	Brake Horse-power.	Water used per Hour.	Water used per Brake Horse-power per hour.
		Boiler.	Engine.				
		Pounds.	Pounds.			Pounds.	Pounds.
1	$\frac{1}{4}$	78	70	1,616	4·63	239	51·74
2	$\frac{1}{4}$	115	100	1,609	7·35	327	44·50
3	$\frac{1}{4}$	159	143	1,600	11·43	449	39·29
4	$\frac{1}{4}$	196	188	1,588	14·96	569	38·09

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
JUNE 9TH, 1900.

MR. WILLIAM ARMSTRONG, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting and reported the proceedings of the Council at their meetings on May 26th and that day.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. JOHAN AUGUST BRINELL, Chief Engineer, Fagersta Iron and Steel Works, Fagersta, Sweden.

Mr. R. E. CHAMBERS, Mine Manager, Bell Island, Conception Bay, Newfoundland.

Mr. EUGENE COSTE, Mining Engineer, 34, Madison Avenue, Toronto, Ontario, Canada.

Mr. GEORGE HENRY EVANS, Mining, Civil and Mechanical Engineer, Breckenridge, Colorado, United States of America.

Mr. WALTER TWINING HOLBERTON, Mining Engineer, Copiapo, Chile.

Mr. JOHN KIRSOPP, Junr., Mining Engineer, Cook Inlet Coal-fields, Homer, Alaska; and Allerdene, Lamesley, Gateshead-upon-Tyne.

Mr. JOHN ALEXANDER McDONALD, Civil, Mining and Mechanical Engineer, c/o Messrs. R. Williams and Company, Bulawayo, Rhodesia, South Africa.

Mr. WILLIAM EDWARD ROWLANDS, Engineer, 16, Penmaier-Glas Road, Aberystwyth, South Wales.

Mr. FREDERICK CARL WEHNER, Mining and Metallurgical Engineer, 5, Alexandra Terrace, Stanley Road, Wallington, Surrey.

ASSOCIATE MEMBERS—

Mr. JAMES ERNEST BLAIR, 1, Wool Exchange, Basinghall Street, London, E.C.

Mr. WILLOWS HILDRED, 25, Melgund Road, Highbury, London, N.

DR. THEODOR LORENZ, Hamburg-Hohenfelde, Papenhüderstrasse, 5, Hamburg, Germany.

STUDENTS—

Mr. MATTHEW ROBSON KIRBY, Student Mechanical Engineer, c/o Mr. A. L. Steavenson, Holywell Hall, Durham.

Mr. CHARLES HERMAN MERIVALE, Colliery Apprentice, Togston Hall, Acklington, Northumberland.

Mr. GEORGE ROBERT OSWALD, Mining Pupil, 106, Senhouse Street, Maryport, Cumberland.

Mr. ALFRED OSBORN WRAITH, Mining Student, Moor House, Spennymoor, County Durham.

The SECRETARY read the Balloting List for the election of officers for the year 1900-1901.

BENEVOLENT FUND.

Mr. M. W. PARRINGTON explained that the Council proposed to establish the fund on similar lines to that in connexion with the Institution of Civil Engineers, established in 1864, and whose accumulated funds now amounted to over £40,000.

AWARDS FOR PAPERS.

The SECRETARY read the following list of papers communicated during the year 1898-1899, for which prizes of books had been awarded by the Council to the authors:—

"The Western Interior Coal-field of America." By Mr. H. Foster Bain.

"The Transvaal Coal-field." By Mr. William Peile.

"The Ore-deposits of the Silver Spur Mine and Neighbourhood, Texas, Queensland." By Mr. H. G. Stokes.

NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

EXCURSION MEETING,

DERBY, OCTOBER 11TH, 1899.

The members met at Derby, and visited the All Saints works of Messrs. Davis & Son, and the Haslam Foundry.

MESSRS. DAVIS & SON, ALL SAINTS WORKS.

The works have been reconstructed, and nearly every tool in the shops has been recently purchased with the view of ensuring greater accuracy of work and economy in production. The works are entirely devoted to the production of apparatus used in mining operations; and in the instrument department the members viewed in the course of construction theodolites of various designs, miners' dials, surveying-levels, anemometers, etc. Safety-lamps were being turned out in great numbers. The firm have for some time been engaged in applying electric power in mining-operations, and they have erected hauling- and pumping-plants and coal-cutting machines. In the foundry, the metals cast include iron, aluminium, gun-metal and brass. A large number of motors were seen in course of construction, and many of them were intended for use on travelling-cranes in engineering works; others were of a type used for driving machine-tools in shipyards and other works. The visitors also saw the process of manufacturing switchboards, switches, water-tight fittings for electric-lighting and power-transmission, and electric-blasting apparatus.

HASLAM FOUNDRY AND ENGINEERING COMPANY, LTD.

The company have been the originators and pioneers of cooling-appliances which render possible the transportation of meat, fruit and other produce from one end of the world to the other. Refrigerators have also been introduced into hospitals, breweries and other buildings of different kinds. The firm are also manufacturers of steam-engines and boilers, hydraulic presses, pumps, machine-tools, tanks, cranes, etc.

NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

EXCURSION MEETING,

SMETHWICK, NOVEMBER 22ND, 1899.

The members visited the works of the New Conveyor Company, Limited, and the Corporation Gas-works.

THE NEW CONVEYOR COMPANY, LIMITED.

The works consist of two main buildings formed of H-iron uprights roofed with corrugated sheeting: the light being obtained from windows in the sides running the whole length of the shops. One of the shops is provided with two cranes of a capacity of 10 tons each; while in the erecting-shop there are two cranes, each of 5 tons capacity. The pattern-shop is built of brick, with timber and slate roof; and the drawing-offices are on the second floor.

The foundry, 1[illegible] feet long by 5[illegible] feet broad, is built of brick, with cast-iron window-frames and Belfast roof. There is a quick-running crane of 5 tons capacity. The engines for driving machinery to work the cupolas are placed in an adjoining building. The dressing-shed is served from the foundry by a light-gauge railway. The new erecting-shop, 1[illegible] feet long with a 50 feet span, is built of brick, with a Belfast roof similar to that of the foundry. In this there is also a 5 tons crane. The electric lighting plant is situated near the boilers.

The machinery consists principally of hydraulic plant for making conveyors, overhead cranes, elevator-buckets, colliery-tubs, etc. There is an accumulator, double acting pumps, and a powerful 100 tons press. In the erecting-shop there is a very powerful set of rolls, 15 feet long by [illegible] in diameter. Spirals can be coiled by machines, from 4 inches [illegible] 4 feet [illegible] from bars varying from 1½ inches to 4 inches.

THE SMETHWICK CORPORATION GAS-WORKS.

The members inspected the first installation of automatic inclined retorts erected in Staffordshire. The hot-coke conveyor is formed by a tapered cast-iron trough, made in lengths varying from 4 to 6 feet, and fixed conveniently below the mouthpieces of the inclined horizontal retorts. The bottom of the trough has a raised portion running lengthwise, forming a small gutter ; into this the coke-dust falls, and is conveyed by means of push-plates or scrapers to the breeze- or dust-collecting-box fixed at the delivery-end. The central part of the trough on which the endless chain slides is formed of ironwood in double strips : the top strip being secured to the lower one in a way which admits of easy renewal. The chain is formed of alternate ordinary oblong links and flat steel section bar links. Each of the oblong links is made from a bar of round steel, bent to fit into the openings in the flat bar links. The endless chain travels on the wooden path all along the trough, and round the driving or end-drums in the usual way, and back over the rollers carried by hangers under the trough-slings or standards. The coke-carrying plates are about 1 inch longer than two links, so that a neat joggle is formed to overlap each plate, and they present a nearly level belt-surface on to which the hot coke falls. The plates form a moving bottom to the trough, by which the coke is conveyed along at a speed of about 30 feet per minute. The dust falls between the edges of the plates and the sides of the trough into the lateral gutters, whence it is removed by the push-plates fixed at intervals of 4 to 10 feet to the underside of the plates. As the machine is at work conveying and slaking the coke along the trough, the push-plates or scrapers also scrape the coke-dust along the gutters, and deliver it out at the end of the trough. There are four beds of inclined retorts, and all the others are ordinary horizontal retorts ; but the coke from both is carried to the end of the retort-house and into the elevator, and thence to the overhead conveyor, which delivers it through the coke-screen to the barges or to the storage-yard.

NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,

HELD AT THE NORTH STAFFORD HOTEL, STOKE-UPON-TRENT, DECEMBER 18TH, 1899.

MR. J. C. CADMAN, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The annual reports of the Council and of the Finance Committee were read as follows :—

ANNUAL REPORT OF THE COUNCIL.

The Council of the Institute have pleasure in presenting their Annual Report. During the past year there has been a decrease in the membership of 9 : the total retirements from all causes being 24, and the newly elected members numbering 15. The Institute has lost since July, 1898, by death, 3 members and 1 associate ; by retirement, 16 members, 1 associate member and 3 associates ; and 1 associate has been transferred to the list of members, and 3 students to the list of associates.

The following table shows the alterations that have taken place :—

	Year 1897-8.	Year 1898-9.
Honorary Members	5	5
Life Member	1	1
Members	112	106
Associate Members	4	5
Associates	46	43
Students	14	13
Totals	182	173

General meetings have been held in the months of October (special), November (annual), December, May and July. Excursion meetings were held in May at the Cresswell colliery of the Bolsover Colliery

Company, Limited; in October at Derby, to Messrs. Davis & Son's, All Saints works and the Haslam Foundry; and in November to Smethwick, where the members visited the engineering works of the New Conveyor Company, Limited, and the Corporation gas-works.

The following valuable papers have been read and discussed at the general meetings during the year:—

"Remarks on the New Rules for Detonators as proposed by the Home Secretary." By Mr. W. N. Atkinson.

"Presidential Address." By Mr. J. C. Cadman.

"The Application of Condensers to Winding-engines." By Mr. W. Freakley.

"Supplementary Notes on the Application of Condensers to Winding-engines." By Mr. W. Freakley.

"The Compounding of Colliery Winding-engines." By Mr. W. Freakley.

"Supplementary Notes on the Compounding of Colliery Winding-engines." By Mr. W. Freakley.

"Notes on Coal-cutting Machinery in Use at Foxfield Colliery." By Mr. B. Parker.

"Horizontal Thrusting in Joints, Mineral Veins and Faults in the North-west of England." By Mr. C. E. de Rance.

"The Genesis and Matrix of the Diamond." By Mr. C. E. de Rance.

Useful discussions also took place on papers read before The Institution of Mining Engineers.

The annual general meeting of The Institution of Mining Engineers was held in Birmingham in September, 1898, and two General Meetings were held, the one in London in May last, and the other in Stoke in February, when many interesting papers were read and discussed, and a successful meeting was brought to a pleasant close with a series of visits to Sneyd colliery and brickworks, Birchenwood colliery, the Hatton water-works of the Staffordshire Potteries Water-works Company, and to the works of Messrs. F. Winkle & Co., and Messrs. Minton & Co.

The annual distribution of prizes to the students attending the mining classes of the Staffordshire County Council took place on November 11th last. The presentation was made by Mr. Frederick Geen, ex-Mayor of Stoke-upon-Trent. Mr. Thomas Turner, director of technical instruction for the Staffordshire County Council, was present, and in his address called attention to the need of some facilities for obtaining a higher instruction in science, contrasting North Staffordshire with other districts.

It may be of interest to members to know that on June 20th, 1899, at a meeting of gentlemen interested in education from various parts of North Staffordshire, a committee was appointed to consider and report

on the educational needs of North Staffordshire and to form an estimate of the cost of any scheme which might be recommended. As a result of careful inquiries into the facts, an exhaustive report was published, in the hope that it might lead to prompt and generous effort to meet a widely felt and increasing want.

The Council refer with regret to the resignation of Mr. J. Richard Haines, Secretary, who has held the office for the past 27 years, he being one of the founders of the Institute.

The Council have again to urge upon the members to use their best endeavours to provide interesting and useful papers, to introduce new members, and in every possible way to assist in making the meetings more interesting and attractive. In order that the younger members may be encouraged to do their share, the Council are pleased to announce that the President, Mr. J. C. Cadman, has generously offered to give a prize of £3 3s. to that student or associate, under 25 years of age, who shall write the best paper read before the Institute.

The Council have also decided to award an annual prize of £5 5s. to the member who shall write the best paper read at one of the meetings of the Institute.

ANNUAL REPORT OF FINANCE COMMITTEE.

For the year ending July 31st, 1899, the receipts from subscriptions and arrears (less £6 6s. 0d. subscriptions for next year paid during this year), amount to £230 15s. 1d., or £15 8s. 11d. less than the receipts for 1897-98, while the expenditure has amounted to £252 17s. 11d.; and the balance in the bank stands at £132 16s. 10d., as against £148 13s. 8d last year.

The sum of £53 1s. 6d. has been written off the arrears' account as being irrecoverable, yet the subscriptions in arrear amount to £133 3s. 11d., only £5 11s. 1d. less than the amount outstanding last year. The Council particularly wish to call the attention of the members to this, and to point out that unless the subscriptions are paid promptly it will soon become impossible to carry on the Institute.

The reports were adopted.

ELECTION OF OFFICERS, 1899-1900.

Col. STRICK, C.B., Mr. T. E. STOREY and Mr. RIGBY, the scrutineers, reported the following appointments :—

PRESIDENT.

Mr. J. C. CADMAN.

VICE-PRESIDENTS.

Mr. W. N. ATKINSON. | Mr. T. M. FAVELL. | Mr. JOEL SETTLE.

COUNCIL.

Mr. T. ASHWORTH.	Mr. G. A. MITCHESON.
Mr. J. R. HAINES.	Mr. J. J. PREST.
Mr. J. HEATH.	Mr. W. STATHAM.
Mr. G. P. HYSLOP.	Mr. J. T. STOBBS.
Mr. J. LOCKETT.	Mr. F. SYLVESTER.
Mr. J. MADDOCK.	Mr. B. WOODWORTH.

TREASURER.

Mr. H. R. MAKEPEACE.

SECRETARY.

Election deferred.

The following gentlemen, having been previously nominated, were elected :—

MEMBERS—

Mr. JAMES LINDAY, Works Manager, The Stafford Coal and Iron Company, Stoke-upon-Trent.

Mr. DAVID PEARSE, Mechanical Engineer, The Stafford Coal and Iron Company, Stoke-upon-Trent.

Mr. ROBERT TURNBULL, Agent, The Stafford Coal and Iron Company, Stoke upon-Trent.

ASSOCIATES—

Mr. HERBERT GRAINGER, Miner, 10, Maud Street, Fenton.

Mr. WILLIAM PLANT, Fireman, 67, Albert Street, Fenton.

The PRESIDENT read the following address :—

PRESIDENTIAL ADDRESS.

By J. C. CADMAN.

I have pleasure in alluding to the work done by our Institute during the past year, and I may congratulate the district on the continued improved condition of trade, which has every appearance of remaining with us for the next few years.

It was more desirable than ever that both owners and managers should consider the absolute necessity of laying out and adopting the most improved labour-saving appliances both above and below ground, which would help to reduce the cost of production, so as to enable them to meet a falling market. Here I may remark how very conservative many mining and mechanical engineers are in not adopting new and economical types of machinery. The tendency to retain old machines if they were in good working order, rather than replace them by those of a more modern and economical type, was very great, even when the saving in many cases by so doing would in all probability repay the cost of replacing in a short time. This was a matter to which greater consideration would have to be given owing to the very considerable increase in the cost of production brought about by advanced wages, foreign competition, the Workmen's Compensation Act, and other causes.

There was no doubt that engineers were now beginning to take up the matter, and I note with pleasure that Mr. R. H. Wainford, one of our late members, had realized this fact, and had brought out and patented a new mechanical apparatus for casting pig-iron at blast-furnaces, and I believe that one of our largest ironmasters was now putting down this plant, which would mean considerable saving of manual labour.

Improvements must be continually made to meet the changes previously referred to. One thing I may here specially mention, namely, the adoption of coal-cutting machinery. This I am firmly convinced would have to be more universally adopted, and owing to the great improvements in the transmission of power, namely, electrical, by the polyphase system, and compressed air by compounding, the great difficulties once attending its use were now almost a thing of the past.

The North Staffordshire coal-field was supposed not to lend itself to the general adoption of coal-cutting machines, owing to the great variation of inclination of the strata; but even here, in opening out a new colliery or making fresh recoveries, the levels and airways could be cut by machinery more economically than by manual labour and with greater rapidity, which was of the utmost importance in the opening out and development of a new colliery.

The Black-band ironstone-seams of this district, however, might, I think, be under-cut with advantage by machinery, each seam having a coal, varying from 1½ to 2½ feet thick, lying with great uniformity under the ironstone, which had to be holed out before the stone could be blasted. Much difficulty was now being experienced in getting skilled labour for this class of work, and I feel sure that ironstone-raisers would do well in giving this suggestion their most serious consideration.

Even the most sceptical mining engineer must admit that a considerable saving could be brought about by the adoption of holing and heading machines where practicable, and the advancement of electrical and mechanical engineering has surmounted obstacles which at one time were considered insuperable. If this use of machinery only reduced the cost by 1d. per ton, it would mean a saving in North Staffordshire of about £26,000 per annum, and if the same saving could be applied throughout Great Britain it would realize the large sum of about £900,000 per annum.

I strongly urge that more general attention should be given to the utilization of all bye-products produced at collieries and iron-works. As an illustration, members should consider what had been done during the last few years by the utilization of the waste-gases of the blast-furnace, which many remember blazing away at the top of the furnaces of our district and illuminating the surroundings. These gases were now collected and used for generating steam, for heating the blast, and now they were being used direct in the cylinders of specially constructed gas-engines, for producing all the power required for the working of the blast-furnace plant, abolishing entirely the use of steam boilers, and consequently reducing the cost and risk. I have given this as one of the many examples, which could be cited of the utilization of bye-products.

Although the trade of the country had been admittedly good during the past year, there had been a reduction in the output of coal in Great Britain to the extent of 77,000 tons. The total amount of minerals raised during 1898 was 215,161,954 tons, as against 215,145,025 tons in 1897, shewing an increase of 16,929 tons, due to the increased output of

ironstone. North Staffordshire showed an increase of 362,566 tons of minerals wrought, and it employed 654 more persons in 1898 than in 1897.

Although North Staffordshire showed advantageously compared with the rest of the United Kingdom, I still believe that with greater facilities for the transit of materials, these figures would be very considerably improved.

I have great pleasure in congratulating H.M. inspectors of mines upon the results of their labours. In Mr. Atkinson's report for 1898, 20 fatal accidents were recorded in the North Staffordshire district compared with 25 in the previous year, and it was remarkable when we considered the hazardous district over which he presided that no accident caused the loss of more than one life. The following table shows the position of the North Staffordshire Mines Inspection District as compared with the United Kingdom :—

Mines Inspection Districts.	North Staffordshire.	United Kingdom.
Death-rate from accidents per 1,000 persons employed	1·227	1·284
Number of persons employed per fatal accident - -	815	854
Number of persons employed per life lost - - -	815	779
Tons of mineral raised per fatal accident - - -	252,812	259,857
Tons of mineral raised per life lost - - - -	252,812	236,962

These results must be considered highly satisfactory to all responsible for the conduct and management of the mines. I believe that credit is also due to the more intelligent way in which the workmen carry out the instructions given them by those in charge, and also from the fact that they take a greater interest in the safe conduct of their work, and I venture to hope that this improvement will continue.

The Workmen's Compensation Act had now been in force a complete year without any, or very little, friction in our district, and I feel sure if the men would comply with the requirements of the Act that no uneasiness or litigation was likely to occur ; but should unscrupulous people attempt by false representation or otherwise to take advantage of that which was provided for honest workmen they must expect no consideration from their employers.

Since the last annual meeting, when I suggested the founding of a college of science for North Staffordshire, a committee had been

appointed to consider and report upon the question. Whether this committee was a sufficiently large and representative one to deal with this very important question, or likely to bring it to a successful issue was questionable, but they were to be congratulated on collecting a large amount of information which I hope in the near future will be of value. It seemed a pity that with the vast wealth of North Staffordshire the whole of the manufacturers could not be persuaded to take an interest in this important scheme for the welfare and advancement of the district.

Although the Institute had not conducted any special classes for mining students during the past year, the County Council had continued its work in this direction with good results. I have heard from many quarters of the excellent teaching given by Mr. J. T. Stobbs, and should like to impress upon all employers and managers the desirability of encouraging young miners to attend these classes so conveniently arranged.

In conclusion, I must allude to the retirement of the Secretary (Mr. J. R. Haines), who had held that position for upwards of 25 years, in fact, with the exception of two years, during the whole of the time that the Institute had been in existence. Mr. Haines was one of the original members, of which only five now remained. I should like to record the fact that Mr. Haines, with Mr. J. S. Wilkinson, our first president, Mr. J. Lucas, and a few others were the first to suggest the formation of our Institute, and were its actual founders.

Mr. WILLIAM HEATH moved a vote of thanks to the President for his address.

Mr. W. N. ATKINSON, in seconding the motion, remarked that the President's address was deserving of careful consideration, especially with reference to the adoption of labour-saving appliances.

The motion was agreed to.

Messrs. J. GREGORY and J. T. STOBBS read the following "Notes on the Kœpe System of Winding":—

NOTES ON THE KŒPE SYSTEM OF WINDING.

By JOHN GREGORY AND JOHN T. STOBBS.

The instances in which the Kœpe system of winding has been applied at British collieries are so few in number that the authors feel no apology will be necessary in giving publicity to a few particulars relating to an efficient application of the system at the Sneyd colliery, Burslem. They can do this with all the greater confidence seeing that the plant in question has now been in daily operation for upwards of 17 years, and during that period those responsible for its adoption have seen no reason to regret their decision. In the face of its extensive application on the Continent and its several undoubted advantages, it appears somewhat strange that the system has not attracted more attention in this country.

In this paper, however, the authors do not seek to combat any prejudices that may exist against its use, but rather to record the actual performances and capabilities of a working plant, and to place them before the members in an unbiassed form. Whilst preserving neutrality regarding its merits in comparison with the drum in ordinary cases, it would be readily conceded that circumstances might arise in which there could be no question as to its adaptability; and for the benefit of members who may be called upon to decide as to its adoption under such special circumstances, the authors have given more pr minence to the practical working details than would be warranted in a general discussion on the system.

General Description.—As is well known, the system is in effect an endless rope applied to winding in a vertical shaft. A single rope, with a cage attached to each end, forms the winding-rope proper, and passes partly round a driving-pulley connected with the winding-engine, this pulley being the equivalent of the drum in the ordinary system of winding. A second or tail-rope is attached at each end to the underside of the cages, and passes partly round a return or jockey-pulley at the bottom of the shaft (Fig. 1, Plate XXIII.).

The energy necessary for the purpose of winding is communicated

from the winding-engine to the endless rope by the friction generated between the rope and the groove of the driving-pulley, which is secured to the crank-shaft of the engine.

Details of the Present Application.—The system is applied at No. 3 pit, Sneyd colliery, and the depth to the inset, or hanging-on, is 1,110 feet.

The winding-engine has two coupled horizontal cylinders of the usual type; and prior to its conversion to the Kœpe system, it had been used for sinking the shaft at which it is now winding. The engine was not designed for permanent winding at this pit, it being the intention at the time when it was erected to ultimately use the engine for haulage-purposes; and although of sufficient size to enable the sinking to be completed, with the steam-pressure available it was not equal to raising the load and unbalanced rope when coal-drawing commenced. It was therefore necessary either to discard this engine altogether for a larger one, or to adopt some means of balancing the additional weight, so that the effective moment of the starting-load could be reduced.

After careful deliberation, and acting on the advice of the manager (Mr. John Heath), to whom the credit of the existing arrangements is due, it was decided to convert the engines to the Kœpe system; and this was accordingly done by building up a ring of cast-iron segments on the old drum in such a manner as to form a V-grooved pulley. Since, amongst other factors determining the efficiency of the system and the limits within which it will work, the angle of the V-groove and the material on which the rope beds, are of importance, an enlarged section of this groove is shown in Figs. 2 and 3 (Plate XXIII). As will be seen, the angle of the groove is 21½ degrees, and the tread of the pulley is lined with hempen rope.

The following are the principal data relating to the application of the Kœpe system at the Sneyd collieries:—

Cylinders	two
,, diameter	16 inches
,, stroke	48 ,,
Steam is cut off at	0·625 stroke
Boiler-pressure, maximum	80 pounds per square inch
Driving-pulley, circumference	30·9 feet
Weight of empty cage and chains	17 cwts.
,, 2 empty tubs	9 ,,
,, 2 loaded tubs	31 ,,
Total weight of empty cage and 2 tubs	26 ,,
,, loaded cage and 2 tubs	48 ,,

Winding and tail-ropes, circumference	3½ inches
Weight of each rope	21 cwts.
Tension on ascending rope entering groove of pulley, including weight of rope, chains, cages, 2 tubs and coal	69 cwts.
Tension on descending rope leaving groove of pulley, including weight of rope, chains, cage and 2 tubs	47 cwts.
Return or jockey pulley in the sump, diameter ...	4½ feet
,, ,, ,, weight ...	12 cwts.
Time occupied in winding	38 seconds
Maximum number of windings per hour, including changing of tubs	90

As an instance of the speed of winding and the facility of working, it might be mentioned that at various times 90 complete runs had been made in 1 hour in the ordinary course of coal-drawing.

The winding-rope was of plough steel, 3½ inches in circumference, and the two ends were secured to the two cages respectively by six ⅝ inch bridle-chains. This rope (Fig. 1, Plate XXIII.) was crossed between the driving-pulley and the pit-head sheaves, namely:—It passes from the underside of the driving-pulley to the top sheave in order to obtain the maximum arc of contact in the grooved driving-pulley. In this particular instance the arc subtends a circular angle of 3·93 radians.

The balance-rope was of the same size and weight as the winding rope, and was suspended under the cages by four bridle-chains ⅝ inch in diameter. The only tension on the balance-rope, beyond that accruing from its own weight, was due to the weight of the jockey-pulley, which was free to slide up and down (Figs. 4 and 5, Plate XXIII.). New ropes were not put on as balance-ropes, old winding-ropes being quite as suitable for the purpose.

In the arrangement at Sneyd colliery, the jockey-pulley was entirely immersed in the water standing in the sump, as water-drawing by means of a tank on the cage was resorted to. This position did not, however, conduce to the life of the balance-rope, and when possible a preferable arrangement would be for the rope to be kept dry.

Special Working Conditions.—These naturally presented some special features, and the use of a single winding-rope was attended with several difficulties not experienced in the ordinary method of winding. The principal points of interest were:—

(1) Changing ropes.—The operations attendant on a renewal of ropes

were somewhat more complicated than when two separate winding-ropes were used, and the method adopted was as follows :—The top cage was first raised about 4 or 5 feet above the level of the pit-bank, and supported in that position by means of packing. Glands were then placed on the rope hanging in the shaft and attached to blocks, by means of which it was raised. This allowed the rope attached to the top cage to become slack, and it was then detached from the cage and secured to a capstan-engine, or as was the case at the Sneyd collieries, to the original drum of the winding-engine. The rope hanging in the shaft, not having been sufficiently raised to take the weight of the bottom cage, the bottom capping could then be detached from the cage and the old rope withdrawn from the pit. The new rope having been coiled on the drum of the capstan or winding-engine, was then lowered down the shaft by that means. The lower end was ready capped, and was immediately attached to the bottom cage. The weight of rope in the shaft was then supported by the blocks, and after the requisite length had been carefully measured, the remaining end was capped and attached to the top cage. When putting on a new rope, the length was so adjusted as to allow of about 3½ feet of large-link chain being interposed between the capping and one of the cages. In practice this was found a sufficient allowance in the first instance for the stretching of the rope, and the length of the chain was reduced link by link as necessity arose. The time occupied in putting on a new rope was about 4 hours.

The renewal of the tail-rope required much less time, and the whole operation could generally be completed in about 1½ hours. The new rope was taken down the pit on a reel, with one end ready capped, and was secured to the bottom of the lower cage in place of the old rope. The winding-engine was then set in motion, and as the new rope was uncoiled the old one was put on a reel at the opposite inset. By so doing, the balance in the shaft was maintained during the whole time.

(2) Life of winding-ropes.—The life of a winding-rope, on an average was about 4 years : a result which might be considered remarkable when it was remembered that the work was practically twice that of a rope worked on the ordinary system. The factors contributing to this effect were :—(*a*) The sheaves were always in line with the rope, thus avoiding lateral movement and consequent side friction between the rope and the groove of the pulley ; (*b*) the stress to which the rope was subject was more constant, and one would therefore expect that the fatigue of

elasticity, and its associated conditions, would be later in arising; and (c) as the rope was not coiled round the pulley, it was subjected to less bending than in ordinary cases.

(3) Slipping of winding-rope on drum.—Under the most favourable conditions slipping of the rope on the drum was found to occur more or less, although with due precautions its effects were so slight that it did not present any serious difficulty in the working of the engine. The tendency to slip was dependent, amongst other things, on the material forming the tread of the pulley, the lubrication of the rope, atmospheric conditions (such as the occurrence of rain or frost), the difference of load on each end of the rope, the arc of contact between the rope and the pulley, and also to a large extent on the manner in which the engineman controlled the engine. Its effect was also more apparent in a series of runs when the load was most unequal on the two sides, more particularly in water-drawing—an increment of slip being added during each winding.

In practice it had been found that the best material for forming the tread of the driving-pulley was hemp. A rope of this material $1\frac{5}{8}$ inches in diameter was used, and driven with a mallet into the groove of the pulley. This rope required renewal at varying intervals, but on an average, once a month was found to be sufficient.

If pure oil were used for lubricating the winding-rope, it materially increased the tendency to slip, and consequently a mixture of American natural oil and Archangel tar in equal proportions was preferred. With this preparation the slip was hardly appreciable.

Heavy rain, also, had a slight tendency to increase the amount of slip; and in winter, after the engine had been standing for some time, hoar-frost might form on the rope in the shaft, and this collecting in the groove of the pulley would materially reduce the co-efficient of friction between the rope and the driving-pulley. But this effect was only temporary, as the slight heat resulting from the slipping, and the increased pressure to which the ice was subject, was sufficient to thaw any snow or ice that may have gathered on the rope.

The engineman was largely responsible for the efficient working of the system, and much depended upon the care with which he controlled the engine. By suddenly throwing on full steam he could easily cause an excessive amount of slip, indeed, under the worst conditions, equal to about half the circumference of the driving-pulley.

If from unavoidable circumstances or through inadvertence, slipping

had taken place during a wind the indicator was speedily rectified, when the difference was equal to the circumference of the driving-pulley, by taking off one lap of the indicator-cord. It might be noted that the tendency was invariably for the indicator to gain on the winding-rope, and hence the liability to overwind was even less than in the generality of cases where the rope was firmly attached to the drum. In other words, the indicator denoted the "end of the journey" before such actually was the case, if slipping had taken place.

(4) Performance of the winding-engine.—As the ropes, cages and tubs on the ascending and descending sides were balanced, there only remained the net weight of the coal for the winding-engines to raise; and it would be seen that this remained constant during the wind, so that the load on the engine was uniform throughout.

This constant load entails steam being admitted to the cylinders during practically the whole of the run, and the cylinders could be so proportioned as to run at their maximum power throughout the wind. Thus much greater economy in steam could be effected than when the load was constantly varying and the maximum power only exerted for a few seconds after starting.

These facts were shewn graphically in Fig. 6 (Plate XXIII.), where the work done by the steam and the work done on the load during each revolution of a winding were represented in the diagram, the abscissæ being the revolutions of the engine, and the ordinates the moments of the load and of the piston-effort respectively during each revolution in foot-tons. Since the moment of the load was constant during the journey it was represented by the horizontal line *AG*. The mean moment of the piston-effort was represented by the line *BCDFH*, which was horizontal as far as the thirtieth revolution, after which it gradually diminished till the loaded cage reached the surface. The work done on the load, proportional to the area *FGH*, was abstracted from the energy stored in the engine, cages, etc.; and as the area *FGH* was equal to the area *DEF*, it followed that the lost work during a winding was proportional to the area *ABCDE*. This lost work was absorbed in the friction of the engine; friction and inertia of the cages, pulleys, ropes, etc.; and might be regarded as mainly representing waste entailed in securing a suitable speed of winding.

Hence, smaller engines being used (especially in the size and weight of the drum and parts concerned in rotary motion), a reduction was effected in capital outlay.

(5) Overwinding.—There was much less likelihood of serious damage being caused through overwinding than in any other system of winding. Assuming that the engine was not stopped, the instant that the bottom cage came in contact with the beams, the tail-rope would exercise a retarding effect on the ascending cage, and at the same time the winding rope would surge in the groove of the driving-pulley, due to its slackness. Detaching-hooks were therefore not required, and would, indeed, prove rather a source of danger than otherwise.

Working Limits of the System.—A common remark by numerous visitors on seeing the system at work was an expression of surprise that the friction of the rope in the driving-pulley should be sufficient to raise the load. Hence, it was thought that it would be of interest to determine the limits within which this would be the case. For this purpose, members must bear in mind, as shewn earlier, that the load was identical at every position in the wind, as the effect of the varying weight of the winding-rope due to depth was thus eliminated. One might consider that there was acting at each end of the arc of contact a force equal to the sum of the weights of the cages, tubs, and a length of rope equal to the depth to the jockey-pulley.

If one were to take an elementary arc δs, the tensions at whose ends are T and T + δT, (Fig. 7 Plate XXIII.), we find:—

By resolving tangentially $\quad \delta T = \mu R \delta s, \quad . \; . \; . \; (1)$

" " normally $\quad T = R \dfrac{\delta s}{\delta \theta}, \quad . \; . \; . \; (2)$

where μ is the co-efficient of friction, say 0·2 for steel rope on oiled hemp; θ, the angle (in circular measure) subtended by the arc of contact; and R, the normal pressure on the trod of the pulley. From equations (1) and (2) we get

$$\frac{\delta T}{T} = \mu \delta \theta, \quad . \; . \; . \; . \; . \; . \; . \; . \; (3)$$

and integrating (3) between the limits T_2 and T_1, we obtain the well known formula

$$\frac{T_2}{T_1} = \epsilon^{\mu \theta}, \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; (4)$$

where ϵ is the sum of the exponential series, namely, 2·718. . . . If the rope does not rest in the trod of the pulley, but is held by the sides of the groove, it may be shown that (4) becomes

$$\frac{T_2}{T_1} = \epsilon^{\mu \operatorname{cosec} \frac{\phi}{2} \theta}, \quad . \; . \; . \; . \; . \; . \; (5)$$

where ϕ is the angle of the groove of the pulley. It will be seen that the latter arrangement increases considerably the holding-power of

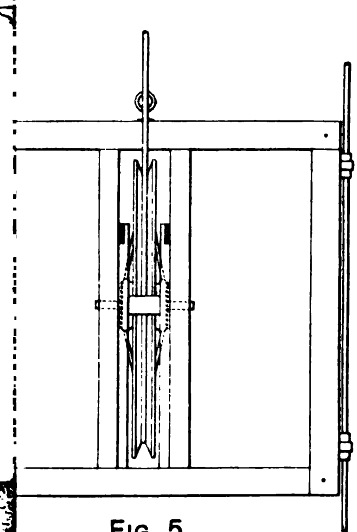


Fig. 5.

Fig. 7.

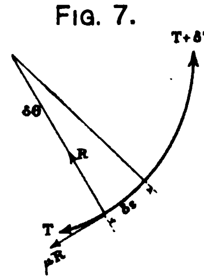
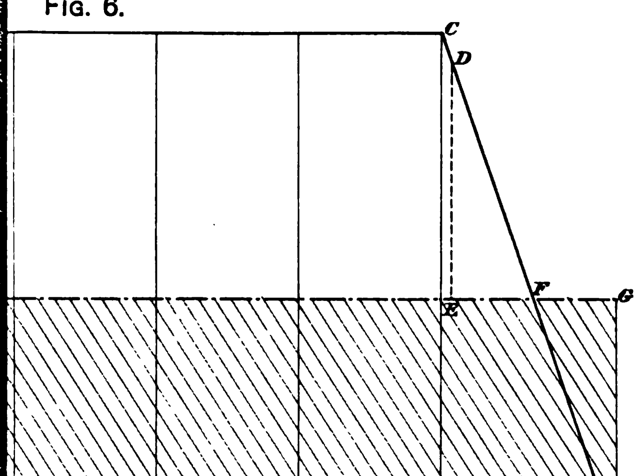


Fig. 6.



the pulley; but the injury to the rope deters its adoption in such arrangements as the one under consideration.

From (4) it will be seen that if $T_2 - T_1$ be not greater than $T_1(\epsilon^{\mu\theta} - 1)$ the rope will not slip.

In the application described, θ is 3·93 radians, and the value of $\epsilon^{\mu\theta}$ is nearly 2·2; therefore if $T_2 - T_1$ be not greater than 1·2 T_1, slipping will not take place. In practice T_2 is 69 cwts., and T_1 is 47 cwts.; and under these conditions, therefore, there ought theoretically to be no slipping if the difference of the loads be not greater than 56 cwts.

In conclusion, it will be well to summarize the advantages and disadvantages of the Kœpe system respectively. The advantages comprise: — (1) Perfect counterbalancing, so that the load is constant throughout the wind. (2) Less liability to overwind. (3) No safety-hooks required. (4) No catches or keps required. (5) The small inertia of moving parts due to the reduction of the size and the weight of the drum, etc., with the result that the maximum speed of winding is quickly attained, and full steam is kept on till nearly the end of the journey; and for the same reason the engine is most readily brought to a standstill. (6) As a corollary to (5), a smaller engine is sufficient for the performance of the required work. (7) The smaller space occupied by the winding arrangements.

The disadvantages comprise:—(1) If the rope breaks during the wind, both the cages are precipitated to the bottom of the pit; however, there is no recorded instance of such an accident. (2) The slight extra time and cost of capping and changing ropes. (3) The inconvenience attending slight adjustments of the indicator. (4) The extra stress on the capping due to the weight of the tail rope. (5) The risk to each load through the failure of both cappings. And (6), it is less suitable for raising or lowering heavy machinery, which is occasionally necessary.

Mr. A. M. Henshaw proposed a vote of thanks to Messrs. Gregory and Stobbs for their valuable paper.

Mr. B. Woodworth seconded the motion, which was cordially agreed to.

Mr. R. Oswald's paper on a "New Ventilating Fan," was read as follows:—

NEW VENTILATING FAN.

By R. OSWALD.

This design of a ventilating fan consisted of a cylinder mounted on a horizontal shaft. The cylinder formed a boss, upon which the blade (or blades) was built. The blade was made in the form of a continuous screw-thread from one end of the cylinder to the other and attached thereto. The cylinder, with the blades, was mounted in bearings and fitted at one end with a crank or pulley for attachment to the engine or driving power. The cylinder was placed in a casing closely fitting the blades except at the lower sides, where the casing was enlarged to form a water-tank, and this tank was filled with water up to or a little above the under side of the boss, so as to form a water-seal for preventing the formation of an induced air-current. The lower part of the casing was suitably enclosed for the purpose of retaining the water, but the upper part was open at one end for the inlet of air, and the other end was open for its delivery, and either opening might be connected by suitable means to the air-shaft or air-pipes, and either exhaust or induced ventilation might be obtained. The object gained was a continuous delivery of the current of air produced by the rotation of the blades without the drawback of back-slip common to other types of fans.

A model of the newly-designed fan was exhibited.

NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT THE NORTH STAFFORD HOTEL, STOKE-UPON-TRENT,
FEBRUARY 12TH, 1900.

MR. J. C. CADMAN, PRESIDENT, IN THE CHAIR.

Mr. J. RICHARD HAINES proposed a vote of condolence with the family of the late Mr. Frederick Silvester in their bereavement. Mr. Silvester was one of the oldest members, and had in his time rendered valuable services to the Institute.

The motion was seconded by the PRESIDENT, supported by Mr. W. BOULTON, and agreed to.

The minutes of the previous General Meeting were read and confirmed.

Mr. W. G. Cowlishaw, Etruria, was nominated as a member of the Council, in the place of Mr. F. Silvester.

Messrs. F. R. Atkinson, G. P. Hyslop and A. S. Heath were nominated for the office of secretary, Mr. Haines having resigned. The election was ordered to take place at the next General Meeting.

It was unanimously resolved that Mr. A. M. Henshaw be elected a Vice-President.

The following gentlemen, having been previously nominated, were elected :—

MEMBERS—

Mr. FRANCIS FOSTER FORSYTH, Colliery Manager, Stafford Coal and Iron Company, Limited, Stoke-upon-Trent.

Mr. ELI STEELE, Mining Engineer, St. Peter's Chambers, Stoke-upon-Trent.

The members visited the power-station and works of the Potteries Electric Traction Company, Limited, Stoke-upon-Trent.

POTTERIES ELECTRIC TRACTION COMPANY: POWER-STATION AT STOKE-UPON-TRENT.

The Potteries Electric Traction Company have an extensive scheme in course of construction, and the system, when complete, will be 35 miles in length, connecting the towns of the Potteries with each other and the surrounding district, the population of which is estimated at 385,000.

The power-house is situate on the site of the original tramways-depôt. The tramways run from this centre to Hanley, Burslem, Goldenhill and Smallthorne, to Newcastle, Silverdale and Chesterton, to Hanford, and to Longton and Blythe Bridge, though as yet the whole of the system is not open for traffic.

The plant consists of four multipolar dynamos, each with a capacity of 220 kilowatts, driven by three horizontal compound condensing engines. Ejector-condensers are used, and are supplied with water by a centrifugal pump, directly coupled to a motor.

The trolley-cars are fitted with two motors (each of 25 horsepower) mounted on cantilever-trucks.

All the feeders had been laid on the Callender solid system, and consisted of single-conductor cables, insulated by vulcanized bitumen and jute, and having a heavy tape protection, laid in wooden troughs, which were then filled solid with Trinidad bitumen.

NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD AT THE NORTH STAFFORD HOTEL, STOKE-UPON-TRENT,
MARCH 12TH, 1900.

MR. J. C. CADMAN, PRESIDENT, IN THE CHAIR.

The minutes of the previous General Meeting were read and confirmed.

Mr. F. R. Atkinson was appointed secretary in place of Mr. J. Richard Haines, who had resigned.

Mr. W. G. Cowlishaw was elected a member of the Council in the place of Mr. F. Silvester, deceased.

DISCUSSION OF MR. W. H. CHAMBERS' "NOTES ON GOB-FIRES."*

THE PRESIDENT observed that the mines in North Staffordshire were worked under peculiar conditions, owing to the acute angles of dip of the coal-seams, and each gob-fire in that district had to be dealt with on its merits. They could not adopt a hard-and-fast rule there like they could in the Derbyshire and some of the other coal-fields, where the gob-fires could be loaded out or extinguished by water. In North Staffordshire, gob-fires often occurred in inaccessible places, in drifts and steep workings, and required more careful handling than in any other district. Almost every gob-fire in North Staffordshire was attended by explosions of gas, many of them certainly very small, but some had caused loss of life.

* *Trans. Inst. M.E.*, vol. xviii., pages 154 and 404.

Mr. W. N. Atkinson (H.M. Inspector of Mines) agreed with what the President said about dealing with gob-fires in North Staffordshire. One of the chief points which struck him in connection with the paper was that Mr. Chambers advocated that the only efficacious method of dealing with a gob-fire was to dig it out. The first case given was an instance where a gob-fire was dealt with by closing the shaft and pouring down carbonic acid gas for several weeks; then closing the shaft completely for as many months; but when the mine was opened and the ventilation was renewed, the fire was as bad as ever. Mr. Chambers took that as a case showing the difficulty of dealing with a gob-fire by stopping it off: but he did not give the time during which the shafts were closed. He said many months, but that was a vague term; nor did he show how the shafts were sealed. Putting scaffolding in a shaft was liable to give an idea of sealing it off when it was not really sealed, and it was not a very good method. As to providing for the cooling of the hot coal by substances which would absorb the heat, the only thing that could be applied in that way appeared to be water. If water was applied it would be in connexion with an attempt to deal with the fire by a direct attack—digging it out. The principles laid down by Mr. Chambers in his paper* might be well enough for the cases with which he dealt; but they were not of universal application, because when a gob-fire occurred in an inaccessible place and in a seam liable to give off a great amount of fire-damp, the danger of dealing with a fire in such conditions in a dusty pit was very great. It was not only the risk of a small explosion of gas, but the risk of such an explosion extending in dusty workings and resulting in the abandonment of the pit, as had occurred in North Staffordshire more than once. Mr. Chambers gave sixteen instances, nearly all of which were dealt with by applying water and digging out the fires. In two cases fatal explosions resulted; in one case a man was killed by white-damp, and in another case two men were killed by a small explosion. The probability was that the nature of the strata in which the fire occurred had a great deal to do with the best and quickest way of dealing with it. If the gob was full of small material and the position of the fire could be located within narrow bounds, and if water could be got to it, or even sand, such a fire might be dealt with. But when a fire occurred in a steep gob, with a firm roof which fell in great blocks, a wider view had to be taken than was laid down by Mr. Chambers' paper.

* *Trans. Inst. M.E.*, vol. xviii., page 155.

Mr. E. B. Wain observed that in the mine to which Mr. Chambers referred the seam contained something like 7 feet of coal. There was a thin and inferior coal got in the goaf, and a very weak roof, so that the gobs would be filled with small material that would help to locate the fire and prevent it from spreading. There were circumstances which would perhaps make it easier to deal with fire by filling out. With regard to sealing shafts, he had a case in mind where a shaft 1,000 feet deep was filled to the top, and he was able to prove that there was a circulation of air, although there was 1000 feet of *débris* in the shaft. Until the top of the shaft was puddled with clay there was a circulation, as proved by the water-gauge in the other shaft.

The President asked whether the circulation was behind the bricking?

Mr. Wain replied that the brickwork had fallen.

Mr. Jas. Maddock said that his first experience with a gob-fire was rather a singular one. The old gob had been drowned for 75 years. It was a steep mine, and the first gob-shot brought down some coke, affording evidence that the gob had been on fire, previous to its being drowned by water. In three months' time, with the second gob-shot there came down red-hot coke, and the mine was sealed up again. Three or four years later, they had a gob-fire in a similar seam, it was sealed for 3½ years, but in less than 6 hours after being re-opened the flames were so intense that it had to be closed again. He had had experience in the Bullhurst seam, where there was a gob-fire and a terrific explosion; it was sealed, the shaft closed, and it remained closed till this day. Afterwards a new system of getting the Bullhurst seam was adopted on the west side of the district, which was a gassy and dusty seam and very liable to gob-fires. The panel system had been successfully in operation for fifteen years, without the slightest show of gob-fire or gob-heat. He thought that "prevention was better than cure;" although at times a little coal might be lost, it was preferable to lose it rather than lose the whole pit.

Mr. Joel Settle stated that the mines in this county were not adapted for filling out any fires which might occur. Twelve or fourteen years ago he had a district in a mine where they thought they could get over the seat of a fire and localize it, but the progress was slow. It was in the Bullhurst coal-seam, 12 feet thick. They got to the seat of the fire somewhat successfully, but had to abandon it. He was

satisfied that the system in force at Bunkers Hill colliery of working out the top end and charging the goaf with gas as it was worked out was a good one, as the gob-fires were somewhat minimized. He had tried the system and in every case it had proved successful. To-day at Birchenwood collieries a goaf was charged down with gas at a temperature of 86° Fahr. It was necessary to watch that no ventilation passed through the goaf. Although they had at the present time two districts in the Seven-feet Bambury coal-seam charged with gas, there was one of the sweetest return air-ways it was possible to find in any colliery. He believed that a district subject to spontaneous combustion should not have too many openings, and preparatory stoppings should be made in readiness, so that in case of fire it could be sealed off in the shortest possible time. He had seen a gob-fire arise without any previous indication that such a thing was likely to occur. It was the duty of the colliery-manager to be prepared before a fire did happen. They should stick to the principle of not working out too large an area at once, so that in the event of a gob-fire the sacrifice would not be too serious, and the risk would be reduced to a minimum.

Mr. A. M. Henshaw agreed with a remark which had been made to the effect that remedies suitable for application to a gob-fire in a particular seam in Yorkshire or Derbyshire would not apply to 1 per cent. of the gob-fires in this district, because no two were quite alike. Although the Bullhurst seam was most susceptible, very few of the gob-fires were of the same character. At Talk-o'-th'-Hill collieries, there were 17 gob-fires in 15 years, all of them attended with considerable risk and trouble and anxiety to all concerned. The Bullhurst seam was very variable, being in some cases 4 feet, in other cases as much as 15 feet thick, and in one special case including inferior coal above it, the thickness of the seam was about 30 feet. Loading out a gob-fire would be hazardous, especially in seams where the presence of explosive gas was probable, and accumulations of gas in places was uncertain. One of the most disastrous gob-fires occurred in solid coal on a narrow heading driven in the coal. Mr. Chambers would have taken proceedings to fill that out, but he would not have been successful in that particular case. It would have taken too long, and he did not think a man should dare to work a pit and be loading out such a gob-fire.

Mr. W. N. Atkinson said there were very divergent opinions as to how long it would be necessary to close a gob-fire before it could be opened.

He thought that it would be interesting to have a record of all fires, which had been reopened after being sealed up; but it would be difficult to obtain reliable records, because so much depended (1) upon the area of the fire, which might not be known; and (2) upon whether the place had been actually sealed hermetically or not. He was struck with what Mr. Maddock said concerning a pit which had been sealed up for 75 years. Did Mr. Maddock intend to imply that there was fire in the pit all that time?

Mr. MADDOCK replied that during the first three months after the reopening coke was got; but afterwards they began to find red-hot coke.

Mr. W. N. ATKINSON, said that another gob-fire had been mentioned which had been sealed for 3½ years. Before drawing any conclusion from it, he should like to know something about the gob-fire and how it was sealed. It was a question whether it was actually sealed hermetically so that no air could get to it, or whether it was merely built off with stoppings, and air might filter through the stoppings or broken strata or in other ways. There was no doubt that if a fire was not hermetically sealed and the air prevented from gaining access, there would be no limit to the time during which the fire might continue. On the other hand, there were many cases where fires had been sealed, and upon the place being reopened the fire was found to have been extinguished.

Mr. JOHN CADMAN said that the author of this paper spoke of an accumulation of white-damp, and of setting a man to watch for it.* There seemed to be some mistake here, as according to Dr. Haldane as little as 2 per cent. of white-damp would asphyxiate a man, whilst a light was not extinguished until a mixture of 11 per cent. was reached. It was improbable that a man could look for this gas when there was no means of indicating it, other than by a mouse which was overcome in 1½ minutes by a 0·04 per cent. mixture. Probably by white-damp the author meant a mixture of black-damp with a small percentage of white-damp.

It would have been interesting if the writer had given some analyses of the coals and his theory as to the origin of the fires described. It appeared that the majority of these fires were probably caused by oxidation of pillars of coal left in the goaf, stimulated and encouraged by pressure.

Little notice seemed to have been taken of the important part which

* *Trans. Inst. M.E.*, vol. xviii. page 158.

moisture played in the production of gob-fires. Several gob-fires in this district (in the Bullhurst coal-seam) had been traced to no other cause than the action of moisture on the Bullhurst hustle. He (Mr. Cadman) had analysed a sample of hustle, from the vicinity of a gob-fire in the Bullhurst seam, and he found that it contained 3·2 per cent. of sulphur equivalent to 6 per cent. of iron sulphide (probably marcasite) which oxidizes readily on the access of moisture to the sulphate, and as this pyrites was mixed with carbonaceous matter, it was probable that the carbonaceous matter obtained the supply of oxygen for its oxidation from the so-formed sulphate, thus oxidizing it generated sufficient heat to carry on a more rapid combustion. The heat produced by the change from sulphide to sulphate also helped in the reaction.

This well-known hustle contained from 26 to 27 per cent. of volatile matter which distilled over at a remarkably low temperature having the characteristic odour of Bullhurst gob stink.

Mr. John Heath said that he was told on one occasion by the under-manager at his colliery that when he went down the pit between 8 and 9 o'clock in the morning, he perceived a little stink. They ridded out 10 or 15 feet of gob and found the material was so hot that they could not place their hands upon it, so that he did not think it would take more than 12 hours to start a fire in some seams. In the Ash coal-seam, a fire was started from the furnace. It was packed with ashes, and 12 months after there was still some stink coming out of the upcast pit. They made holes and sent in water, and soon afterwards an explosion occurred. A similar fire occurred at another colliery in the Ash coal-seam, except that there was a shorter distance betwixt the upcast and downcast shafts. This fire had travelled about for 14 years, the pits had been twice sealed off for this single fire, and when the rubbish was filled out of the pit bottom, it was so hot that the men could scarcely work. About eight months after his going to this colliery the fire broke out again in the shaft-pillar, betwixt the downcast and upcast shafts, and burned like a blast-furnace. From past experience he feared to turn on water at once, but having steam-pipes in the pit-bottom, he placed several jets of steam on the intake-side of the fire, steam was passed in the day-time and at nights he turned on water, following it up with the pick and shovel. This fire was wholly removed in about 4 weeks working only at the week-ends. No fire was seen afterwards. By this method he was enabled to draw coals every day, and no time was lost.

Mr. JOEL SETTLE said that he had had experience of gob-fires commencing unexpectedly. For instance, on going to work in the morning everything was found in order, but at 10·30 a.m. a gob-fire broke out. It might appear that careful examination should have revealed its presence, but it did not do so. Mr. Atkinson inquired whether there was any case where a gob-fire that had been hermetically sealed off had taken fire again. He (Mr. Settle) had known cases where gob-fires had been sealed, but it was a difficult thing to build off a gob-fire, and prevent air from getting into it afterwards.

With respect to opening out a gob-fire, he could not lay down any rule. He had just restored part of a district which had been sealed off. In this case they approached the workings which were on the rise and the inclination was 30 degrees. They could approach it with suction-air without disturbing the gas which they knew was covering the goaf. They opened that out successfully. Mr. John Cadman had referred to the carbonaceous shale as one of the great evils with which they had to contend. Analysis of the shale from the Minnie pit showed that it was full of oil and a certain amount of coal. He had seen the shale fire itself with the dampness. If they took shale with hustle on to the surface it would fire itself, and when the shale began to heat it would set fire to any surrounding coal.

Mr. T. E. STORY said he remembered a case, in which an underground manager in the Bullhurst seam went to the manager and said that he had got a gob-fire. "Where is it?" enquired the manager, and the reply was, "In the main dip." The hustle had fallen down, and there was a little dampness. The hustle had fallen in a heap, and a fire originated, bearing out what Mr. Settle had stated as to hustle causing fire in the Bullhurst seam whether worked by longwall or any other system.

The PRESIDENT said he had no hesitation in saying that the true mode of working the Bullhurst seam was by the panel system. So far as regarded re-opening he had had some experience. In one case they had a gob-fire, and the seam was closed for 10 years before being re-opened. The workings were filled with gas to the bottom level, and that was tested by a hole put through the stoppings. His opinion was that the chemical action of combustion would lie dormant so long as the place was sealed off, and no air allowed to pass to the seat of the fire, but the moment the place was re-opened, and air allowed to circulate, chemical

action would be restored and there would be a risk of re-starting the fire. The chief danger in the Bullhurst seam existed in the shale or hustle. They had only to look at the Audley district to see the action of the shale, almost every pit-bank heap was on fire.

The further discussion of the subject was adjourned.

MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT THE QUEEN'S HOTEL, LEEDS, APRIL 28TH, 1900.

MR. W. H. CHAMBERS, PRESIDENT, IN THE CHAIR.

The minutes of the previous General Meeting were read and confirmed.

The following gentleman was elected, having been previously nominated :—

MEMBER—

Mr. WILLIAM RIPPER, Professor of Engineering, University College, Sheffield.

Prof. JOHN GOODMAN delivered the following address on "Economy in Steam-engine Practice" :—

ECONOMY IN STEAM-ENGINE PRACTICE.

By Prof. JOHN GOODMAN.*

The subject of steam-engine economy is one of great importance. Fortunately the great points to be looked at in producing economy are, as a rule, very simple; but they are, nevertheless, frequently overlooked, with the result that in many instances engines are found to be actually using five or six times as much steam as a perfect engine would use. Yet, on the other hand, engines can be and are made which only use about 10 per cent. more steam than the perfect engine working under the same conditions: thus there is a vast difference between the best and the worst steam-engine. It is rather humiliating to find that many engines, now in use, give far worse results as regards economy than the old Watt engine, simply because the great principles that Watt laid down are so often ignored.

What then must we avoid and what must we aim at in order to secure economy? First, one must get clear ideas as to the physical properties of steam, and one must constantly bear in mind the fact that steam is an unstable vapour and not a perfect gas such as air. Steam and compressed air when used in an engine behave in totally different ways. However cold or hot the cylinder may be when using compressed air, there will be no "missing quantity" of air; but there may be an enormous loss or "missing quantity" of steam if it be brought into contact with a cold cylinder—or, in other words, much of the steam may be "initially condensed."

It is important to find out exactly what occurs in a steam-engine cylinder. At the instant when the steam is admitted the temperature may be, say, 350° Fahr. and in a fraction of a second afterwards it may be exhausting into the condenser where the temperature is perhaps as low as 150° Fahr.; or there is a range of temperature of 200° Fahr. What has happened to that incoming steam? There are many ways of proving that a large proportion of the steam is condensed as soon as it enters the cylinder, or is initially condensed. One of the most convincing ways of demonstrating initial condensation is to have a glass

* Revised by the author from the shorthand notes of the reporter.

cylinder (known as a "Donkin revealer") fitted to the cylinder of a working steam-engine. The members would be much surprised if they had not seen the action which went on in such a glass cylinder. When the engine is running tolerably slowly, the glass cylinder is simply flooded with water when the steam enters; then during expansion it begins to boil off, known as "re-evaporation," and during the period of exhaust, it disappears and leaves the glass cylinder absolutely dry. But if some means be taken to heat the glass cylinder gradually, one sees that as the temperature of the glass becomes hotter, the flooding of the cylinder gradually becomes less, until at last it entirely disappears, and there is not a trace of condensation taking place in the cylinder

There are tolerably accurate means of measuring the amount of water present, or the amount of steam initially condensed in the cylinder. It is no unusual thing to get 30 per cent. of the steam that enters the cylinder condensed in this way; but in the best engines working under favourable conditions it can be reduced to almost zero.

A more careful examination of the action going on in the cylinder shows that during the admission process, when the incoming steam is hotter than the cylinder walls, the steam imparts some of its heat to the colder walls and gradually raises them to its own temperature; then, as expansion proceeds, the temperature of the steam falls below that of the walls, and a reverse action is set up. The walls now return some of the heat borrowed during the admission period and cause re evaporation to go on; then, as soon as the exhaust-valve opens, the temperature of the steam falls far below that of the walls and every drop of the water formed by the initial condensation is now boiled off—all the steam that is initially condensed is re-evaporated before leaving the cylinder, otherwise the cylinder would receive more heat at each stroke than it gives out, which is, of course, impossible since the mean temperature of the cylinder does not vary after the engine gets steadily to work The steam leaving the cylinder is usually wet, but that is due to the steam being initially wet when it leaves the steam pipe, to radiation and conduction-losses, and also to work being done by the steam in the cylinder.

The initial condensation and the re-evaporation going on in the cylinder constitute a borrowing-and-paying-back process—just the very thing that one does not want. At the beginning of the stroke, when one could make the best use of the steam, a large amount of it is thrown away. A little of it is returned during expansion, but when exhaust occurs, and just when one wants to get rid of the steam as rapidly as possible, the re-evaporated steam appears, producing a back pressure, so

that this condensation of the steam in the cylinder and the boiling of it off again is a loss. The more one can prevent this action the more efficient will engines become.

Another important point which experiment shows is that the volume of steam initially condensed in a cylinder is, roughly speaking, constant, whatever the cut-off may be. Suppose that a cylinder held 1 cubic foot of steam, and steam was supplied during the whole stroke, and say under these conditions that 0·1 cubic foot was initially condensed by the cold cylinder-walls or about 9 per cent. of all the steam admitted. Now if steam be cut-off at 0·5 stroke, one would still have, roughly, 0·1 cubic foot initially condensed, but now it amounts to about 17 per cent. of the steam admitted. Suppose, further, that steam be cut-off at 0·1 stroke, one would still have, roughly, 0·1 cubic foot initially condensed, and 0·1 utilized or 50 per cent. of the whole quantity is initially condensed. Thus the earlier one cuts off the steam, or in other words the greater the number of times that one expands the steam in any cylinder the greater is the loss due to initial condensation.

Many text-books on the steam-engine contain diagrams and figures to show that the more one expands the steam in a cylinder the greater will be the economy, which is utterly false teaching. If it were not for initial condensation and other losses, such a conclusion would be true, but initial condensation is one of the most important points for which we have to look in a steam-engine. Engineers are told that theory and practice do not agree, but as a matter of fact theory and practice do agree marvellously well in steam-engine work.

In the following table of results of tests on a large steam-engine he

RESULTS OF EXPERIMENTS ON A LARGE STEAM-ENGINE WORKING UNDER VARIOUS CONDITIONS.

Ratio of Expansion.	Non-Condensing.				Condensing.			
	No Steam-jacket.		Steam-jacketted.		No Steam-jacket.		Steam-jacketted.	
	Initial condensation.	Steam used per Indicated Horse-power per Hour.	Initial condensation.	Steam used per Indicated Horse-power per Hour.	Initial condensation.	Steam used per Indicated Horse-power per Hour.	Initial condensation.	Steam used per Indicated Horse-power per Hour.
	Per cent.	Pounds.	Per cent.	Pounds.	Per cent	Pounds.	Per cent.	Pounds.
1·00	8	47	3	47	10	36	5	35
1·30	10	38	4	37	10	29	6	28
1·88	13	28	4	26	12	24	7	24
2·65	16	26	5	24	13	20	8	20
3·35	20	26	6	23	15	19	11	19
4·00	23	27	8	23	20	19	14	18
4·53	25	28	10	23	25	19	16	17
5·50	30	31	11	23	30	20	20	17
6·30	35	34	11	24	35	21	20	17

ventures to think that there is more information of real value than in volumes of books which do not deal with this important question from a practical standpoint. The table records the result of tests on a large steam-engine, tested under varying conditions, both when condensing and non-condensing, with and without steam-jackets, under many ranges of expansion.

The points that should be specially noticed are that—

(1) The initial condensation increases rapidly as the range of expansion increases: by a simple calculation it can be shown that the volume of steam initially condensed is approximately constant at all ranges of expansion.

(2) The initial condensation is materially reduced by the use of steam-jackets; and the reduction due to the steam-jacketting is much greater with the high ranges of expansion than with the low.

(3) The steam-consumption decreases as the range of expansion is increased up to a certain point, and then it increases again; the most economical range of expansion is greater with a steam-jacketted than with a non-jacketted engine, and is greater with a condensing than with a non-condensing engine.

(4) With low ranges of expansion, in which the initial condensation is small, the steam-jacket is of but little use, but its efficiency increases as the range of expansion increases.

From this table one sees that it is not desirable to expand steam more than from 3 to 5 times in one cylinder, the most economical ratio depending entirely on the conditions of working. In Lancashire, it is a common practice to design steam-engines to expand the steam in such a manner that the mean effective pressure shall be about 25 pounds per square inch, there being a popular notion that this is the most economical method of working. Nevertheless, it is a fallacy, and actual tests show that 25 pounds per square inch is far too low in most cases. The object of jacketting is to keep the cylinder hot and to prevent initial condensation; but if under any conditions there is but little initial condensation, what is the good of the jacket? The steam-jacket cannot do any good except preventing initial condensation: hence one would expect the jacket to show the best results when the initial condensation is greatest and to show the worst results when the initial condensation is least, which is exactly what one finds from the table. When steam is cut off at the end of the stroke the steam-jacket is of no use, and may be a source of loss, because it increases the radiating surface of the cylinder. Marine engineers often condemn the steam-jacket, they usually cut-off

steam late in the stroke, because they have to reduce the weight of the machinery as much as possible. With so late a cut-off as 0·75 stroke, the saving due to a steam-jacket would probably not be more than 2 or 3 per cent., which would certainly not justify the extra cost. Engineers who say that the steam-jacket is of no value, and those who say that the jacket saves 20 per cent. of the coal-bill, may both be right. The one has had experience with engines having a late cut-off, and the other with engines having an early cut-off. Engineers may safely state that, as a general rule, if the steam be cut off later than 0·5 stroke, a steam-jacket should not be used, while if the steam be cut off earlier than 0·5 stroke it will pay to use a jacket.

Sometimes a jacket is used where it ought to pay, but it does not actually do so, because it is allowed to get full of water, and hence becomes a condenser instead of a steam-jacket. If one uses a steam-jacket, it is of the highest importance to have it thoroughly drained and thoroughly well trapped. There are one or two traps on the market which are more or less satisfactory, but in his opinion, a receiver should be used to collect the water; it should be fitted with a glass water-gauge and blow-off cock, which can be adjusted so as to allow the water to drain away as fast as it enters the receiver.

Some years ago, a well-known firm placed the cylinder of a portable engine in the smoke-box, with the object of preventing initial condensation. It was a success for a time, but in a few days the effect died away, due to a deposit of soot. If the cylinder had been kept clean on the outside from soot (by means of a scraper) it would without doubt have effected a great amount of saving; but there was also the practical difficulty that it was troublesome to get at the cylinder for repairs.

A firm of engineers in Switzerland send many large engines into this country, and some British engineers allege that they are lower priced, but that is not the case, for they are considerably higher in price. In many instances, this firm had tendered for engines and had got much better prices than British makers, because they guaranteed a lower consumption of steam than any British engineer would guarantee. This is because the Swiss firm study every minute detail, and spend much time and thought over every point which helps to increase the efficiency. In this country, these matters are often regarded with indifference, and frequently are spoken of as "theoretical humbug," but they have turned the scale in favour of the Continental engine. However, there is more than one firm in Great Britain who realizes the importance of close study of the theory of the steam-engine, and has already achieved great things.

Another important point is worthy of attention. Sometimes one sees hot water and steam-radiators for heating buildings fitted with external gills or flanges, in order to increase the radiating-surface; and it is well known that they radiate the heat more rapidly than a perfectly smooth pipe. In the radiator, one wants to radiate heat, and in the steam-cylinder one does not want to radiate heat. Hence to get the least amount of conduction and initial condensation one must have plain flat pistons and covers, not even allowing a nut to project on the piston, in order to reduce the surface to a minimum. The piston and interior of the cylinder-cover should be polished: some engineers even nickel-plate the surfaces in contact with the steam in order to reduce condensation. Others polish the outside of the cylinder-covers, but from an economical point of view, it far more important to polish the inside. These are little points, but they add materially to the economy of the steam-engine.

Another way to obtain economy by which the initial condensation loss can be entirely got over is by superheating the steam. One may roughly estimate the saving by superheating as 20 per cent. for every 100° Fahr. of superheat.

One cannot dismiss the question of combatting initial condensation of steam without referring to the most important of all the developments in the steam-engine, namely, that of expanding the steam in two or more stages, as in the compound engine. A full treatment of the compound engine would occupy too much time, but a glance at the main reasons why a compound engine is more economical than a simple engine which expands the steam the same number of times, cannot be other than instructive. It must be well within the memory of most engineers that text-books and engineering-journals used to scoff at the idea of a compound engine being more economical than a simple engine working under the same conditions; and this curious blunder arose from the fact that steam was regarded by them as a perfect gas instead of a very unstable vapour. Suppose one has a simple engine in which the steam is expanded say 16 times in one cylinder, one will then probably get about 50 per cent. of initial condensation; but if it be expanded in two stages, or cylinders, the same total number of times, that is expanded say 4 times in each cylinder, the initial condensation would be reduced to about 20 per cent. in each cylinder. But 20 per cent. in each cylinder is not 40 per cent. in all, as the steam condensed by the walls in the first cylinder is all boiled off during the exhaust into the second cylinder, and all the steam that enters the first cylinder as steam leaves as steam—except for minor losses, etc., which need not be considered.

Consequently, although 20 per cent. is condensed in each cylinder, it is only 20 per cent. in all the cylinders against 50 per cent. in the simple engine. There are other reasons why the compound engine is more economical than the simple engine, but the one just mentioned is the most important.

There is yet another way of preventing initial condensation, namely, by using a type of steam-engine in which there is practically no variation in the pressure and temperature of the steam which comes into contact with any one part of the motor. In the steam-turbine, the steam plays on a series of small blades for an exceedingly short space of time and then escapes to the exhaust or to a second series of blades; and each series of blades is thus kept at approximately the same temperature, and consequently no cooling or initial condensation of the steam occurs. There are other losses in the steam-turbine, but the results obtained are wondrously economical. The steam-turbine, working with superheated steam and condensing, is more economical than any high-speed engine. Many engineers seem to think that the steam-turbine is but a toy; but, as a matter of fact, such turbines are very economical and cost little for repairs. He knew of steam-turbines which have been at work for eight or nine years driving a mill, and the proprietors speak in the highest terms of them for economy of maintenance and steam-consumption.

It is astounding that engineers will erect high-class engines and boilers so as to secure economy, and then cover the steam-pipes with cheap material, little better than dung, instead of having the pipes thoroughly well-clothed. Tests show that for every 100 feet of steam-pipe 8 inches in diameter, badly covered, the consumption of coal is about 20 tons per annum higher than when the pipe is covered in the best possible manner.

Steam-pipes are usually too large: in one case a pump was erected about 1,500 feet distant from the boiler, at the bottom of a well. The steam-pipe was 4 inches in diameter, but the pump would not work satisfactorily. It was decided, after careful consideration, to take out the 4 inches pipe and substitute one 2½ inches in diameter, and the pump afterwards worked perfectly. He did not say that all steam-pipes are too big, but there is a distinct tendency to make them too big. Within reasonable limits, the smaller the steam-pipe the better, because the surface for condensation and radiation is less, the velocity of the steam is greater, and it has less time to condense. Consequently, the steam is delivered to the engine in a very much drier state than when it has

passed through a bigger pipe. It might be urged that there is a serious loss of pressure by using a small steam-pipe, but with a tolerably small pipe, and a well-clothed receiver placed near the engine, there will be very little loss of pressure, as there will be a steady flow of steam through the small steam-pipe during the whole time instead of a rush just during the admission-process. It is better in every way to have a small-drop in steam-pressure than to get very wet steam at the engine. It is an easy matter to calculate the most suitable diameter of a steam-pipe, but no simple general rule can be laid down.

The friction-losses of steam-engines are often much greater than they ought to be: many engines only give 75 per cent. of mechanical efficiency, and 25 per cent. of their whole power is wasted in friction, but he knew of cases in which the loss is far greater; and on the other hand he had made tests of an engine in which the friction-losses only amounted to 7 per cent. The bearings in that case were fitted with white metal, because the friction of white metal is lower than that of gun-metal or bronze. Lubrication should be attended to more carefully than is the rule. Ring lubrication is excellent, and so also is pad lubrication, as the pad removes grit and gives good results. In many high-speed engines the oil is supplied by a force-pump.

Other essential details include the balancing of slide-valves, keeping cylinder-clearances small, reducing the back-pressure to a minimum, and paying great attention to the bearings of an engine.

There is no need for purchasers of steam-engines to go abroad for thoroughly good workmanship and high economy, for more than one British firm could supply engines that would give results within a fraction of a pound of steam as good as any that are made elsewhere.

The PRESIDENT proposed a vote of thanks to Prof. Goodman for the lucid way in which he had placed this subject before the members.

The motion was cordially approved.

Mr. G. B. STONES read the following paper on "Hydraulic Cage-loading and Unloading Apparatus at Cadeby Colliery":—

HYDRAULIC CAGE-LOADING AND UNLOADING APPARATUS AT CADEBY COLLIERY.

By G. B. STONES.

The output at Cadeby colliery is about 1,800 tons a day, and it is anticipated that this quantity will be increased to 5,000 tons a day (drawn up two shafts) when the colliery is fully developed. The drawing-cages, constructed of steel, have four decks, each carrying two corves containing an average of 10 cwts. each. The decks are loaded and unloaded simultaneously, the top deck by manual labour and the others by hydraulic machinery designed by Mr. W. H. Chambers.

Surface Arrangements.—Figs. 1 and 2 (Plate XXIV.) shew a side elevation and end view of the apparatus employed aboveground. Two similar cages, A and B, having decks corresponding with those of the drawing-cage, are placed opposite each other, and with sufficient space between them to admit the drawing-cage. The duplicate cages on the full side of the shaft are each supported by three vertical rams, C, C and D. The water-pressure is maintained in the outer rams, C and C, while the contents of the central ram, D, are exhausted into an open cistern supplying water to the pumps. By this arrangement there are three rams, C, C and D, employed in raising the cage and load.

When it is desired to lower the cage, the opening of the exhaust-valve of the central ram, D, so reduces the lifting-power that the weight of the cage overcomes the resistance of the outer rams, C and C, and the speed of descent is regulated by the extent of the opening of the exhaust-valve of the central ram, D. The central rams, D, on the full side of the shaft are 6½ inches in diameter, and the outer rams, C and C, are 3¼ inches in diameter. When the main valve is opened, the rams are subjected to a total pressure of about 19,910 pounds, the water being supplied at a pressure of 400 pounds per square inch.

The central rams, E, supporting the cages on the empty side of the shaft, are each 4 inches in diameter. They are always connected with the pressure main, and are used for the same purpose as the rams, C and

C, on the full side of the shaft. The outer rams are similar in construction to those on the full side.

Opposite to one end of the cage, A, employed for the reception of the empty corves, are three horizontal pushing-rams, F, F and F, attached to a vertical travelling-beam, G, fitted with grooved pulleys, H and H, at each extremity, and carried on the rails, I and I. This vertical beam is strengthened by the struts, K and K, which are connected at one end to a shaft carrying the pulleys, L, which run in the grooves, M and M. Between the struts and attached at one extremity is a connecting-rod, N, which is coupled to an arm, O, supported at its lower end by a rocking-shaft and connected near the centre to a ram, P, 4 inches in diameter, sliding in an oscillating case, Q, and held in position by the pedestal, R. Attached to the rocking-shaft, supporting the arm, O, is a lever, S, to which a weight, T, is suspended from one end by a chain. This weight is used for withdrawing the pushing-rams, F, F and F, after the drawing-cage has been loaded.

The motive power for this machinery is obtained from an hydraulic accumulator, charged by a steam-engine, with two cylinders, 16 inches in diameter and 18 inches stroke.

The mode of unloading and loading is as follows:—When the drawing-cage has reached the surface, the banksman releases the catches, W and Y, and the man in charge of the hydraulic machinery opens the valve connected with the ram, P, by means of the pipe, Z. By his so doing, the pushing rams, F, F and F, propel the empty corves into the drawing-cage, and, by their impact, at the same time cause the full corves to run into the cage, B. The time occupied in unloading and loading the winding-cage is about 5 seconds. Whilst the drawing-cage, containing the empty corves, is descending the shaft, the cages, A and B, are raised simultaneously, the cage, B, to be unloaded of its full corves, and the cage, A, to be loaded with empty corves ready for the next arrival of the drawing-cage.

Underground Arrangements.—The motive power for the underground machinery is obtained by conveying water down the shaft through a pipe, 2 inches in diameter, the shaft being 2,250 feet deep; a total pressure of about 3,053 pounds on the rams is obtained from a water-pressure of 972 pounds per square inch, which is sufficient to impel the machinery without the aid of a steam-engine and an accumulator.

Fig. 3 (Plate XXV.) is a side elevation of the underground apparatus, and although the duplicate cages, A and B, are of similar construction to

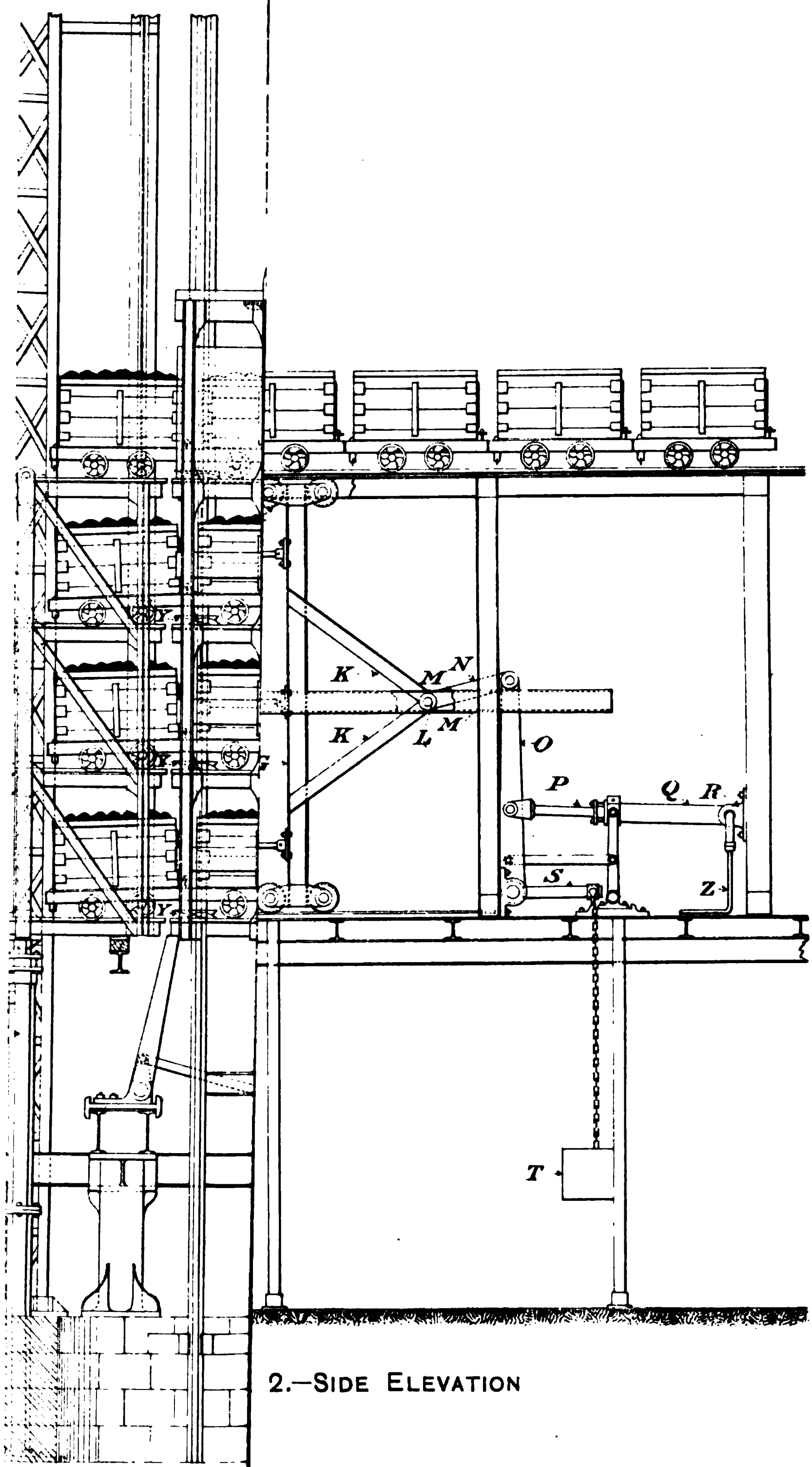
those in use on the surface, a different means of raising and lowering them is adopted. The cage, A, used for the purpose of loading the full corves, is raised (when empty) by the balance-weights, C, which slide on four guides, D, D and D, and they are attached to the pulley, E, by a flat wire-rope, F, passing over the pulley, G. The cage, A, is attached to two pulleys, H, by wire-ropes, ⅞ inch in diameter. When loaded with full corves, the cage, A, descends by gravitation and the speed is controlled by a double brake, I, and the lever, K, the latter being connected to the former by the rod, L.

The cage, B, used for the reception of the empty corves, is raised by two parallel rods, M, attached to a lever-beam, N, and supported by two steel girders (12 inches), O and O. The lever-beam is moved by a ram, P, 5 inches in diameter, sliding in an oscillating case, Q, attached to the beam at a distance of about 5 feet from its fulcrum. The top of the ram, above referred to, is held in position by two parallel girders, R, 10 inches deep, the latter being supported by vertical arms, S and S, and the struts, T, which are fixed at their lower extremities to the girders, O and O. A portion of the lever-beam is formed into a box, U, containing weights, used for the purpose of assisting the ram to raise the cage. When the exhaust-valve of the ram, P, is opened, the cage, B, descends by its own weight.

The machinery employed for loading and unloading the drawing-cage is identical with that in use on the surface, with the exception that the weights, W, are placed on the arm, Y, instead of being hung from it by a chain.

Assuming that the drawing-cage is loaded and ascending the shaft, the cages, A and B, are raised, the former by releasing the brake, I, and the latter by opening the valve, and allowing the water to flow through the pipe, Z, which is connected with the ram, P. The cage, A, is allowed to ascend until the bottom deck is level with the floor, the brake, I, is then applied, and two full corves are run on to the bottom deck of the cage, the brake is then released, and the remaining decks are loaded in the same manner. The cage, B, is raised by applying the pressure to the ram, P, and the decks are successively unloaded.

The writer is informed that a modification is contemplated in regard to the underground machinery. The water discharged from the rams into the shaft-sump entails pumping, and, to obviate this, the brake and balance-weight arrangement on the full-side cages will be replaced by hydraulic rams, exhausting into a water-tank, fixed some distance up the shaft. It is calculated that the descent of the duplicate cages will then



2.—Side Elevation

& Comp^y L^td Newcastle on Tyne

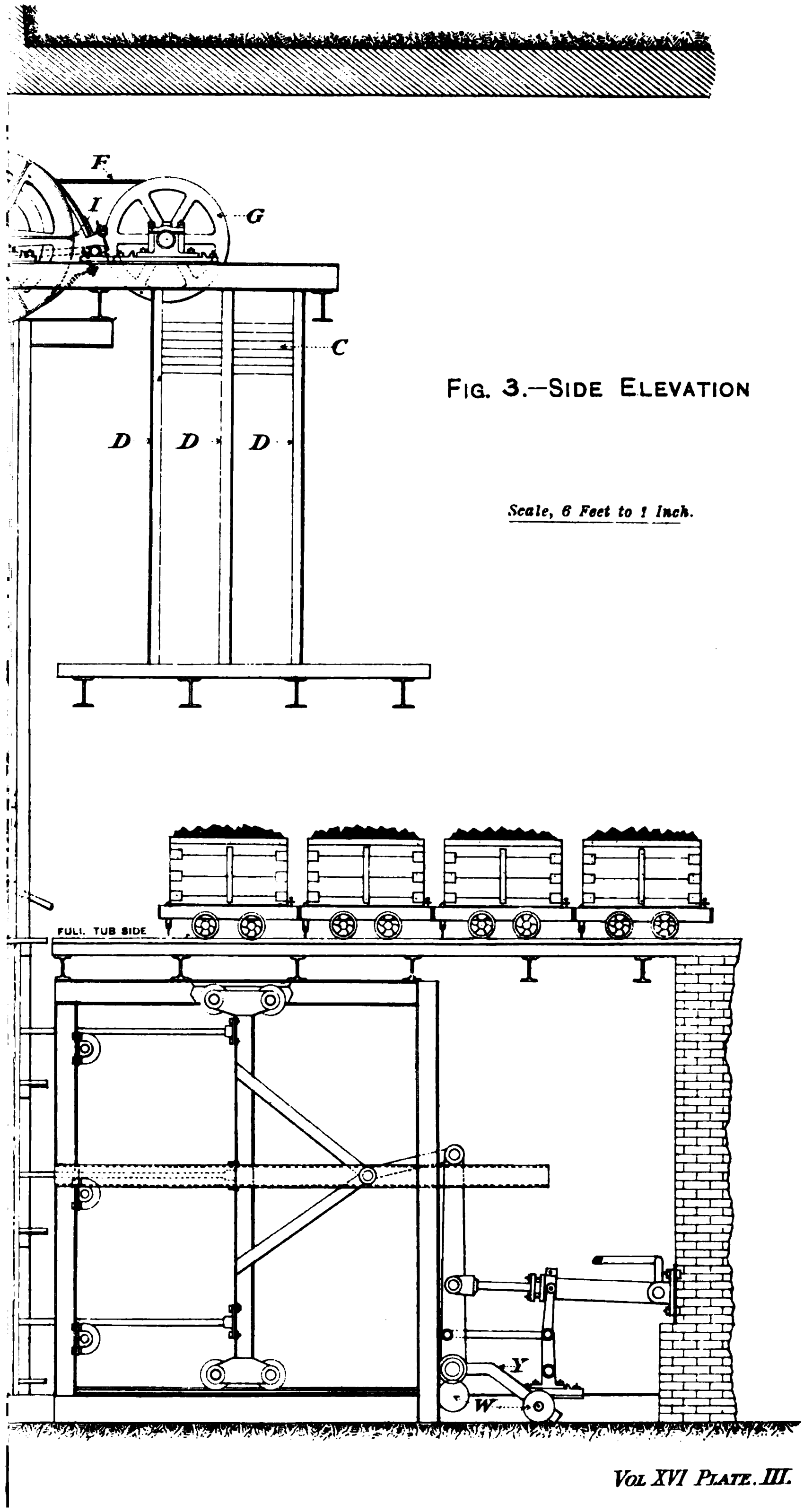


Fig. 3.—Side Elevation

Scale, 6 Feet to 1 Inch.

be better controlled, and sufficient water-pressure stored to supply all demands without waste.

In conclusion, the writer having seen nearly all the systems of loading and banking in operation in this country, ventures to submit that there are advantages in favour of the system here described which are unapproachable by any other :—(1) Economy. Manual labour is minimized by the employment of machinery : the empty and full corves being manipulated with constant regularity and smoothness, and without undue bustle during the time occupied in the journey of the drawing-cage, consequently fewer workmen are required for dealing with the output. (2) Saving of time. The whole of the decks of the cages are simultaneously and quickly charged immediately a "wind" is made. (3) Less wear-and-tear of winding-engines, ropes and tackle. The drawing-cage is always brought to one position on the keps, and it remains there until prepared for the next journey. (4) There is no limit to the number of decks that can be loaded, and, consequently, the winding-shafts need only have an area sufficient to provide adequate ventilation. (5) Efficiency. The machinery is simply constructed and not liable to get out of order. (6) Safety. The whole of the apparatus is under the direct control of one man, who, by means of levers convenient to his hand, manipulates everything, except the actual loading and unloading of the duplicate cages, and this work is under his close supervision. He is also able to see that the catches on the drawing-cage are in order, and everything secure for the next journey before it is "rapped" away.

Mr. W. E. Garforth asked whether the apparatus could be used at the bottom of a shaft which happened to be in faulted ground or on a lifting floor.

The President (Mr. W. H. Chambers) replied that the whole of the machinery was fixed on framing independent of the brickwork and of the shaft, so that nothing could be disturbed by any movement of the strata. At one time the ram, which propelled the lever-beam at the pit-bottom, was fixed to a casting attached to the pit-arching ; but it was replaced by the girder-arrangement.

Mr. W. E. Garforth said that at a certain colliery, an arch, 18 feet high, in a few years was lowered by the weight of the superincumbent strata to 8 feet. They were troubled at a depth of

2,820 feet at New Moss colliery with the arching, they inserted timber between the layers of brickwork, and in that way probably added 2 or 3 years extra life to the arching. He was now in favour of side-walls and steel girders for a pit-bottom.

The PRESIDENT (Mr. W. H. Chambers) replied that the arching at Cadeby colliery did not extend more than 30 or 40 feet in each direction from the shaft-bottom. The greater portion of the shaft-bottom was filled with machinery, and the walling of the shaft did not rest on the arching. There had been considerable trouble with the arching, some had been removed, although it was 5 feet thick and faced with limestone, but it was pushed in 2 feet by side-pressure, and it broke at the crown. Another arch was erected of a horseshoe shape, and the top fell in from side-pressure. Excavations had been made behind the side-walls to relieve the side-pressure, and the space had been filled up loosely with waste prop-ends—something which would yield to the pressure and yet support the walling in its arched shape.

The hydraulic arrangement for simultaneously loading and unloading all the decks of the cages was invented by Mr. George Fowler, who erected the first apparatus at Hucknall Torkard collieries. Mr Fowler designed the machinery erected at Denaby Main colliery about 20 years ago. They had had a great deal of experience with caging machinery; they had improved it considerably, and the Cadeby collieries plant was very different from the plant originally erected at Denaby Main colliery.

The apparatus could be advantageously employed at deep pits; they only required the shaft to be sunk a little deeper in order to allow for the extra decks of the cages going below the floor-level; and they avoided the sinking of a shaft of large diameter with a big pit-bottom, to give room for drawing the tubs side by side. In this case they carried out what was contemplated when the shaft was sunk, and though the shafts were intended to wind a large output, they were only 16 feet in diameter.

Mr. H. B. NASH said that the wear-and-tear of ropes and engines, when the decks were changed, was no doubt the greatest strain put upon the machinery in winding. The members were obliged to Mr. Stones for bringing the details of the apparatus before them, and he moved a vote of thanks to him for his paper.

The motion was cordially approved.

DISCUSSION OF MR. W. H. CHAMBERS' "NOTES ON GOB-FIRES." *

Mr. C. J. MURTON (Barrow Collieries) said that, about ten years ago, a very serious gob-fire broke out in the No. 4 south district of the Parkgate coal-seam, over a very extensive area. It took a long time to effectually build stoppings all round the affected area, but the fire was eventually restrained until about a year ago, when in the return-airway, a strong smell of gob-stink was recognized at No. 2 stopping. It was found that the loose sand-and-clay stoppings, which had been erected in the goaf, had dried, and allowed air to pass through the crevices. Immediately, a large body of workmen were employed in building a line of walling along the intake-airway, and repairing stoppings where it was thought any air, however little, might pass through. At No. 2 stopping, a very strong brick wall, cut into the sides, was built with cement, and backed with sand. Two additional brick walls were also built, well-packed between with sand tightly rammed to the roof. This wall had proved an effective barrier, and had restricted the area of the fire, which had not troubled them since its erection.

The PRESIDENT (Mr. W. H. Chambers) said that they were fortunate in having solid coal at Barrow collieries, in which the stopping was erected. They had adopted the course which he had advocated, the coal not being fissured so as admit air. If they could exclude the air effectually no more danger was likely to accrue, so long as they did not disturb the barrier of coal or the brickwork. His own experience showed that even when a little air had been admitted combustion had been resumed.

RECOVERY OF MINES AFTER EXPLOSIONS." †

Mr. W. E. GARFORTH said that some months ago it was arranged that experiments should be made at the West Riding collieries to ascertain how far men could penetrate into noxious gases. He now wished to explain that in order to make the arrangements of a practical character, he intended to use a gallery, about 100 feet long, sufficiently high to allow for a fall of roof, so that the explorers might have to ascend 8 or 10 feet, and then descend, like passing over a fall in a mine. Nothing, however, further could be done in the matter until the arching was completed.

* *Trans. Inst. M.E.*, 1899, vol. xviii., pages 154, 404 and 461.

† *Ibid.*, 1899, vol. xviii., page 74.

The PRESIDENT said that the members were looking forward to the experiments with interest, and were glad that Mr. Garforth had got the arrangements into so forward a state.

DISCUSSION OF MR. R. HARLE'S PAPER ON AN "AUTOMATIC SPRAYER FOR PREVENTING ACCUMULATIONS OF DUST IN MINES."*

The PRESIDENT (Mr. W. H. Chambers) said that he had a deep, hot, and dusty mine fitted with sprinklers, which sprayed the water, but it made a muddy mess on the roads for a length of 100 or 120 feet, and beyond that distance it had no effect. The spray was like a Scotch mist, but it seemed to fall upon the floor, and did not damp the sides and the roof; and actually where the road was muddy at the bottom there was dry dust on the sides and roof.

Mr. C. J. MURTON stated that the most effective way of damping dust was to empty water-tubs at the top of an incline and allow it to run down, and its effect lasted a long time.

Mr. W. E. GARFORTH said that when giving evidence before the Royal Commission on Accidents in Mines he suggested that the most effective means of preventing dust-ignition was to substitute dirt-dust for coal-dust. If the roads could be covered with incombustible dirt it would be the most effective means of preventing the extension of an explosion.

Mr. J. R. ROBINSON WILSON thought that there was some misconception regarding the scope of Mr. Harle's paper. Dust was made at two places—in the tubs and at the top of the shaft. Mr. Harle suggested the use of an automatic sprayer playing upon the tubs as they left the flat or pass-bye. This appeared to be a very effective method; and it had been tried in Yorkshire, he believed with success. There would be little or no dust on the haulage-roads if they prevented it coming outbye with the tubs; and if a similar arrangement were adopted in the shafts, the fine dust made at the screens would be caught at the pit-bottom. In the return-airways, which were not traversed by coal-tubs, there could not be any dangerous dust.

Mr. W. E. GARFORTH said that the fine, or what he might call sunbeam dust would still be carried by the air-current. At many

* *Trans. Inst. M.E.*, 1899, vol. xviii., page 113.

explosions it had been proved that there had been excess of coal-dust, or not sufficient air to consume all the dust; indeed, roads traversed by an explosion were like sooty chimneys. He thought that whilst the spraying apparatus might moisten three-quarters of the dust the other quarter was sufficient to propagate the flame.

Mr. J. R. Robinson Wilson said that he did not know how to water all the dust on every road, as it was impracticable to water the bars, props, sides, and various cracks in an ordinary road. The only way to his mind was to prevent the dust from accumulating on the roads.

The President (Mr. W. H. Chambers) thought that the best system was to sweep up and send all dust out of the pit.

Mr. E. T. Ingham (Mirfield) remarked that with fast haulage the dust was greater than where the haulage was slow. His haulage ran at the speed of 2 miles an hour and he had little dust, although the seam was dusty and fiery. He was interested in a deep colliery near the sea, and he thought that they should try to lay the dust by spraying salt-water, which would be carried inbye in the ventilating current, and the salt would be deposited upon everything in the mine. He certainly intended to try the effect of his idea, and he hoped to be able to inform the members of the result.

Mr. W. E. Garforth said that he could show Mr. Ingham stalactites 1 foot long, and the roadway below was always free from dust.

Mr. E. T. Ingham said that at the Ingham pit the water was similar to sea-water. They had not a large quantity, but it was used in watering the haulage-roads. Wherever that water had been much used there was no dust. He thought that the salt became mechanically mixed with the coal-dust, and he hoped that it would prevent all liability to explosion.

THE SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING,
HELD IN THE MASON UNIVERSITY COLLEGE, BIRMINGHAM,
JUNE 11TH, 1900.

MR. J. LINDOP, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting and Council Meetings were read and confirmed.

DONATION TO THE BIRMINGHAM UNIVERSITY.

The SECRETARY (Mr. Alexander Smith) reported that he had received a communication from the Honorary Treasurer of the University of Birmingham, acknowledging the receipt of £52 10s. from the Institute for the endowment fund.

THE HAMSTEAD COLLIERY FIRE.

Mr. FRED. G. MEACHEM gave a description of the physical conditions of the mine upon the re-opening of the Hamstead colliery after the fire. The mine fired, and was tightly closed for 15 months. After being re-opened, the air was analysed and was found to consist of 84 per cent. of nitrogen, 12 per cent. of fire-damp, and 4 per cent. of carbon dioxide, or it might be expressed :—Air, 0·61 per cent.; fire-damp, 12·27 per cent.; and nitrogen and carbon dioxide, 87·12 per cent.

When a distance of about 90 feet had been driven, holes, 6 inches in diameter, were bored through a rib, 30 feet thick, so as to ease the pressure. In a few minutes, the air was fouled with gas, and it was a week before the workmen could again approach the place. The gas from the first bore-hole drove the workmen 120 feet down the road, although two air-pipes, 12 inches in diameter, were taking the air away as fast as possible. The gas, issuing from the tap (4 inches in diameter) which had been driven into the bore-hole, made a deafening roar, and the volume given off was about 1,500,000 cubic feet in 24 hours.

When the mine was re-opened it was found that the gases had had no deleterious effect upon the food, or the materials left in the mine, in fact everything left in the mine was found practically undamaged. Bread had become as dry as biscuit, cooked bacon was as fresh as when left, and water in the horses' tubs had not evaporated, although surrounded by perfectly dry coal-dust. Previous to the fire, oatmeal was supplied to men working in hot places to mix with their drinking-water, and this was found to be as sweet as when sent down the pit. The rails and ropes were not rusted. Men's clothing was dry, and in practically the same condition as when left. The under-manager's shirt was fit for use as soon as it was found in his box. In the stables, the chaff was unimpaired, and the horses readily ate it. The timber in the pit did not seem to have undergone any change whatever. In the three months that had elapsed since the re-opening of the mine, greater decay had taken place than during the fifteen months that the pit was closed. It was remarkable that there had been no fires in the mine during the period of closure. While they were constructing the new roads from the shaft they had many "bumps," evidencing a tremendous amount of earth-movement, but no fires occurred, and this, combined with the facts which he had already mentioned, led him to the conclusion that oxygen alone was the active agent producing fires in coal-mines.

Many years ago, it was the custom in Old Hill and other thick coal-seam districts to close the mine and cut off the air-supply during week-ends and other holiday times. Probably, the manager who originated the custom was scarcely actuated by chemical reasons, but his practical experience led him to adopt such a course. When he was a student, however, at Mason University College, he was taught that this practice was altogether wrong, and that he should "Put in more air, and withdraw the heat as it is generated." Now, however, he was inclined to adopt the practice of many years ago and prevent the access of air when the pit was not working. It was surely practicable to close a side of work by doors, say from Saturday till Monday. If the oxygen were absorbed from the pent-up air by barytes or some other chemical, there would be fewer fires, and little or no anxiety during the time that a mine was standing. He thought it possible, too, that their grandfathers were right, for though there was not a fire during the fifteen months that Hamstead colliery was closed, there was one last Saturday morning. He believed that the withdrawal of air during holiday times would be one of the best preventives of fire, and in these days of short hours of

labour they might stop many fires by reducing the amount of oxygen to 15 per cent. when the pit was empty. Such fires as they had had at Hamstead colliery would then be practically impossible, for it was a well-known fact that matches could not light if there was only 15 per cent. of oxygen.

Most of the members present dissented from Mr. Meachem's opinion as to the stoppage of fires by cutting-off the air.

A hearty vote of thanks was accorded to Mr. Meachem for his paper, and the discussion was adjourned.

DISCUSSION UPON "MECHANICAL VENTILATORS."*

Mr. R. S. Williamson moved that the thanks of the Institute be given to Mr. M. Walton Brown for his able paper, and for the interesting manner in which he had recorded the experiments made by the Committee. He thought that it would be desirable to make further experiments on modern quick-running fans, driven by high-speed engines.

Mr. John Field seconded the motion, which was cordially approved.

* *Trans. Inst. M.E.*, vol. xvii., page 482.

APPENDICES.

I.—NOTES OF PAPERS ON THE WORKING OF MINES, METALLURGY, ETC., FROM THE TRANSACTIONS OF COLONIAL AND FOREIGN SOCIETIES AND COLONIAL AND FOREIGN PUBLICATIONS.

THE AGE OF METALLIFEROUS VEINS.

Zur Bestimmung des Alters der Gänge. By Prof. H. Höfer. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen,* 1899, *vol. xlvii., pages* 157-160 *and* 169-171, *with* 2 *figures.*

Mr. J. Arthur Philips' *Treatise on Ore-deposits* gives a general theory of metalliferous deposits, with a sketch of those now known in the whole world; but, although a few pages are devoted to the age of veins, there are but few indications serving to determine that age, and the author thought that it would be useful to discuss the subject.

The formation of a vein corresponds with two distinct phases, the first being the formation of the vein-cleft, and the second its filling. While the former is purely mechanical, the latter is generally chemical; and these two phases must be considered successively with respect to their age. All clefts are caused by an impulse, which has either originated in the enclosing rock or outside it, giving rise to diaclases and paraclases.

The diaclases, due to contraction of the rock, may be caused by cooling down, as in the eruptive rocks, or by loss of matter, as in the drying of wet rocks, or again in some metamorphisms; and the diaclases are in many cases a consequence of the solidification of the rocks, so that they must be regarded as of the same age. Inasmuch as the eruption-age of a massive rock or the deposition-age of a sedimentary rock may generally be determined, the age of the diaclase will also be known. Only in contraction fissures, due to metamorphisms, is it often difficult to determine the age; but the metalliferous deposits of that origin are rare, so that it may be admitted, for most contraction-fissures, that the diaclases are of the same age as their enclosing rocks. The duration of the formation of diaclases in one and the same rock has been relatively short, so that all these fissures may be regarded as of the same age; and, as a reciprocal crossing of the veins due to contraction-fissures has never been observed to the author's knowledge, it may be presumed that the formation of the fissures was completely terminated before their filling began, which would again prove the short duration of the diaclase formation.

It is more difficult to determine the geological age of the paraclases, and consequently that of most veins, especially thick veins; but at any rate they are more recent than the enclosing rock, this difference of age often embracing the duration of several formation-periods. The ancient rocks contain metalliferous veins more frequently than do the recent rocks; and this is due to the fact that the former have been longer exposed to the formation of the paraclases than have the latter. The origin of the paraclases is due to the action of an external force, such as gravity (cleft of subsidence), upward pressure (cleft of

fracture), or lateral pressue (cleft of thrust). The clefts of fracture, caused by increase in the volume of a subjacent rock, are relatively rare, those resulting from lateral pressure being the most frequent.

The following are the characteristics that may serve to determine the age of vein-paraclases:—

(1) It is generally admitted, when a vein stops short at a rock of more recent age than the enclosing rock, that its age is comprised between those of the two rocks; and, although this observation generally holds good, it must not be taken too absolutely.

(2) The preceding case, in which the discordance between two rocks serves to determine the age of a paraclase, leads to a second group of phenomena, suitable for determining the age of a fissure, namely, the existence of a dislocation.

(3) The metalliferous veins which traverse a rock of age A (say Jurassic) are affected by a fault, the age B of which (say Eocene) is known so that the age of these veins is comprised between A and B—say Cretaceous in the example given;—and this observation applies to the case in which the fault is constituted by another and more recent metalliferous vein, the age B of which is determinable.

(4) In sedimentary formations, massive rocks are found in the state of overflow or interstratified (veins and masses), the eruption age of which is known, and when these eruptive masses are traversed by veins, the latter are more recent than the former, and the age of these veins may be precisely determined when the masses are of recent origin; but this is so much less the case as the age of the eruption is farther removed from the present time. On the other hand, the eruptive rock may traverse the vein, and in that case the latter is more ancient than the former.

(5) Let it be supposed that certain veins make their appearance in measures of known age—say Silurian, and that there are, side by side but unconformable, beds of an age also determined—say Lower Carboniferous—containing a bed mixed mechanically with ores exactly like those of the veins—for instance, galena of concordant silver-content. In such case, the veins must have been completely formed before this bed, so that in the example cited the age of the vein-clefts and of the filling is Devonian.

The clefts of a vein-district may be of different age, as proved by crossings, throws, the formation of double or triple veins, or of two veins, one of which was completely formed and therefore filled before the cleft of the other was opened; and the age of two similar veins may differ by several formations. If it be desired to determine as exactly as possible the age of a paraclase, it is not sufficient to study the vein-district; but a profound geological knowledge of the parts surrounding it must be acquired, in order to permit of determining the epochs of great dynamic transformations, because it is very probable that they were accompanied by the formation of several large fissures. At what epoch occurred the principal upheavals, subsidences or out-throws of the vein-districts? An answer to this question will generally solve the problem as to the age of the paraclase.

The second act in the formation of veins, namely, the filling, must in a great number of cases have followed closely on the formation of the vein-clefts, at any rate, at the beginning of this filling; and such is especially the case with diaclases in the eruptive rocks that were formed while the cooling occurred, and at an epoch in which hot water burst in, and perhaps also gases which have contributed to the deposit of vein-minerals. In other cases, the filling must have succeeded closely on the opening of the cleft, without its being possible

very often to say when the mineral formation terminated; and the narrower the veins, the richer were the mineral-solutions, the more favourable were the factors of precipitation, and the more rapid also the filling, it being admissible that, where there was only a crystalline incrustation, the phenomenon was of less duration than in the case of veins containing large and fine crystals.

In most cases, all that can be done is to determine the age of a fissure, because the filling may have extended over a long period, as to the end of which there are rarely any indications. Another guide may be given in some cases by pebbles that may have fallen from the surface into the vein while the vein-minerals were being deposited there; but it is well known that such pebbles are very rare in veins, and it would be a fortunate chance to find one belonging to a more recent age than the sides of the vein.

Another method for ascertaining the age of a vein-mass is exact observation of the point where the vein is covered or cut by a more recent enclosing rock; and in such a case the cleft is more ancient than the cover. If it had not yet been filled, the covering matter would have entered it; and also there might possibly have been an impregnation of the vein's minerals in the cover starting from the end of the vein, while, if the vein was completely filled when it was covered, a clear line of demarcation should be observed at the plane of contact.
J. W. P.

MINERAL RESOURCES OF TRANSCASPIA, RUSSIAN ASIA.

Einige Mittheilungen über die Salzausbeute, Naphthagewinnung und das Vorkommen von nutzbaren Mineralien in Transkaspien. By F. THIESS. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im Preussischen Staate*, 1899, *vol. xlvii.*, *pages* 133-134.

The author starts with a brief physiographical description of the country, and notes that an absence of running streams is characteristic of the plateau of Ust-Urt, which forms the northern and north-western portion of Transcaspia. There salt-lakes and pans abound, while in places fresh water is got by sinking wells. The central portion of Transcaspia, the Kara Kum, is a treeless, sandy, all but waterless plain, lying in part about 145 feet below the level of the Caspian Sea: all the streams, with the exception of the Amu Darya and the Atrek, are lost in the sands of the desert. Very different are the features of the southern portion of the province, which is mountainous and fertile and well-cultivated along the river-valleys.

Salt occurs all over Transcaspia in the form of rock-salt deposits, brine-springs and salt-lakes. It is worked industrially in the districts of Krasnovodsk and Mangishlak alone, being elsewhere used by the inhabitants for their personal consumption. The principal deposits are those of Cheleken and Balla Ishem, where the available mass of salt is estimated to amount to 240,000,000 puds (3,870,000 tons). The principal salt-lakes are those of Mulla-Kara, Kuli which covers an area of 70,300 acres, Kukurt Ata, Kara Baba, Kara Kul, etc. The Transcaspian output of salt in 1895 amounted to 22,000 tons, nearly four-fifths of which was got from the Cheleken deposits. The salt is conveyed thence by way of Usun Ada to the harbours on the Caspian or is exported to Persia.

The existence of naphtha-springs had been ascertained long before the Russians seized upon the country. The mountain-ranges on the eastern shore of the Caspian are regarded as a continuation of the Caucasus, and it is thought that the naphtha-springs on either shore of that sea are the outlets of an enormous subterranean reservoir which stretches right away from the Caucasus

under the Caspian into Transcaspia. The annual output of naphtha in Transcaspia appears to have steadily diminished from 4,669 tons in 1890 to 1,393 tons in 1895. Nevertheless, the author predicts a great future for the industry in that province.

Ozokerite occurs on the Cheleken Peninsula, in the Naphtha Dagh.

Sulphur is found at Damba and Shiik, near Geok Tepe, on the road to Askhabad (Kara-Kum), at Kukurtlinsk, between the railway-stations of Balla Ishem and Mulla-Kara, at the Usun-Ada, and in places along the shores of the Caspian. In the Kara-Kum region about 4,915 tons of sulphur have been got in the years 1890 to 1895. Red and white gypsum is worked on the Krasnovodsk peninsula, the output in 1895 amounting to 1,245 metric tons.

Saltpetre has been discovered at Annáo, galena at Kara-Kala, potters' clay and porphyry at the Techen; it is said, moreover, that iron-ores, copper-ores, and coal-seams occur in Transcaspia, but exact information as to these finds is not yet forthcoming. L. L. B.

GEOLOGY OF THE ISLAND OF RHODES.

Geologische Uebersichtskarte der Insel Rhodus. By GEJZA VON BUKOWSKI. *Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt,* 1898, *vol. xlviii., pages* 517-688, *with* 1 *plate.*

The author gives a detailed description of the geology of this island, which appears to consist of Cretaceous and Eocene limestones, together with more modern alluvial and fluviatile deposits. Among the eruptive rocks, serpentine, diabase, porphyrite have been found.

H. L.

RAR-EL-MADEN IRON-ORE MINE, ALGIERS.

Note sur la Mine de Fer manganésifère de Rar-el-Maden, Province d'Oran. By ED. DIETZ. *Revue Universelle des Mines,* 1899, *vol. xlvii., pages* 165-172.

In his researches into the origin of non-sedimentary iron-ores, the author has always noticed that, when the ferruginous water that has formed the ore by substitution for the limestone was sulphated, gypsum is found in quantities with the ore, and also deposits of gypsum in the neighbourhood of the iron-ore deposit. He even feels justified in stating that such mineral water has metamorphosed the schists while depositing gypsum in their place. On examining the point of contact, the observer may see the various phases of the transformation, in the same manner that shreds of schists and clays are found in the midst of the gypsum; and indeed the stratification of the gypsum resembles that of schists for which gypsum has been substituted.

On the other hand it may be noticed that, when the ferruginous mineral water was bicarbonated, and had acted upon sedimentary or amorphous limestone, crystalline limestone, or marble, is always found in proximity, the marble having doubtless existed in the state of liquid bicarbonate of lime. The small nests, grains, etc., found in this marble are only the result of the crystallization, in which affinity plays the largest part; but these pieces of ore have not fallen into this mass, as is stated in some publications on geology.

When the mineral water contained iron in the state of protoxide, it often happens that the calcareous water forming the residue still contains a certain quantity of iron carbonate, which has crystallized with the calcareous mass, and formed a marble of more or less deep yellow colour on the surface.

The method of formation may also be easily traced if attention be bestowed on the stratification, the inclination and the composition of the sedimentary limestone into which ferriferous mineral water has penetrated. The iron-ore separates from the crystalline limestone, always forming lenticular masses, which follow or touch one another, because the solutions follow the cleavage of limestone before all things; but they also penetrate by their dissolving power across the thin scales of limestone while following a fracture. Accordingly, in the midst of the sedimentary limestone are seen masses of crystalline limestone, or marble; and, if the latter should contain a little iron, and come to the surface through erosion or denudation, it will assume a yellow colour, and delineate fluid forms in the sedimentary limestone, as if the mass had penetrated the limestone in the state of a liquid magma.

J. W. P.

GOLD-BEARING COBALT-VEINS IN THE TRANSVAAL.

Goldhaltige Kobaltgänge in Transvaal. By HANS OEHMICHEN. *Zeitschrift für Praktische Geologie*, 1899, *pages* 271-274, *with a figure in the text.*

The old workings on the Kruis river, a tributary of the Olifants river, some 40 miles north of Middelburg, were opened up again after a lapse of about 20 years by Mr. Dörffel. At the same time, as the result of further prospecting in the neighbourhood, several cobalt-veins were discovered, one of which, the Laatsch Drift vein, is auriferous like that of the Kruis river (originally described by Mr. E. J. Dunn in 1877).

To begin with the Kruis river vein: it is only about 1 inch or so thick, but the country-rock (aplite belonging to the Upper Lydenburg Quartzite group) on either side of the actual vein is richly impregnated with ore to a breadth of 2 feet or more. The vein strikes east and west, pitches 60 to 70 degrees southward, and has been followed for about ¼ mile along the strike. On the hanging-wall side there is a maximum thickness of 7 feet of aplite which is then succeeded by diabase: on the foot-wall side diabases are also interbedded with the aplite.

The ore is silvery-white, and, in the coarsely crystalline parts of the vein, shows a tendency to cleave in three directions: this property, combined with the extraordinary difficulty of fusing the material before the blowpipe-flame cast some doubt on its true character, but chemical analysis shows that it has precisely the composition of smaltine. Auriferous quartz appears here and there as an infilling of the vein-fissure. The average gold-content varies from 6 to 15 parts in 100,000, the cobalt-percentage from 7 to 8, and that of nickel from 0·5 to 1.

The Laatsch Drift vein occurs about 3 miles to the westward of that just described. It goes perpendicularly down through diabase. The vein-stuff is auriferous quartz, containing nests chiefly of smaltine and accessorily of copper-ores. The cobalt-ore is dark grey to black, coarsely crystalline, with barely perceptible cleaveage, fuses easily in the blowpipe, and contains a high percentage of iron. Next in abundance is chalcopyrite, while iron-pyrites and molybdenite occur in very small quantity. The gold-content is stated at 1 to 2¼ parts in 10,000 and assays have led to the conclusion that the precious metal is associated with the cobalt, but that none is to be found in the chalcopyrite, which is, however argentiferous.

The author describes also the Rooival cobalt-vein, which, 5½ miles to the west of the Kruis river vein, strikes perpendicularly to that vein, that is, north

and south. It varies in thickness from 2 to 14 inches and, although in certain mineralogical associations it recalls the auriferous copper-veins of La Higuera in Chile, it does not appear to be gold-bearing.

L. L. B.

IRON-ORE DEPOSITS OF TABARCA, TUNISIA.

Note sur les Minerais de Fer des Territoires des Meknas et des Nefzas (Tunisie). By A. PROST. *Annales des Mines*, 1899, *series* 9, *vol. xv., pages* 533-554, *and* 2 *plates (maps).*

In the territory of the Nefza and Mekna tribes near Tabarca are certain iron-ore deposits which can be exploited by opencast workings, and in 1884 no less than seven mining-concessions were granted for that purpose. Little use, however, had been made of them so far, perhaps because the lessees were discouraged on finding that the ores generally contain a small percentage of arsenic. Meanwhile the progress in metallurgical science and the great recent development of industrial plant and means of transport in Tunisia have induced engineers and others again to turn their attention to a neglected source of wealth. The author being entrusted with the inspection of the Tunisian mines from 1895 to 1898, availed himself of the opportunity to make a careful study of the Tabarca deposits. He divides the seven concessions previously mentioned into two groups:—

One in the Meknas territory, Ras-er-Rajel, lies between the Wadis Berkukesh and Bu-Tarfös, 6¼ miles as the crow flies east of Tabarca. The other group, 19 miles north-east of that port, includes the properties of Bu Lanagg. Jebel Bellif, Wadi Bu Zenna, Tamera, Ganara and Burshíba. The ores are a mixture of manganiferous brown and red hæmatites, occuring in lenticular masses of varying thickness and extent. They lie in argillaceous sandstones which are interstratified with clays: the immediate roof is a white or bluish laminated clay, overlain by Numidian Grits (Upper Eocene). The floor is often a calcareous conglomerate, bound together by a ferruginous cement: below this comes a thickness of 300 feet or more of bluish-grey marls.

The author gives a succint description of the exploration-workings, now mostly fallen in or impassable, based in part on documents preserved in the Government archives, and estimates the available amount of ore that could be worked by opencast, at not less than 4,300,000 metric tons. From the numerous analyses made, 29 of which are tabulated in full, it is seen that these ores, when properly sorted, yield on an average 55 per cent of metallic iron and manganese. The Ras-er-Rajel ore is more particularly rich in the latter metal, the percentage being, in a typical sample, iron 21·01, and manganese 28·72. Moreover the Tabarca ores are nearly as free from phosphorus as those of Bilbao, with which they stand comparison in other respects. The diminished output of the Bilbao mines will perhaps ere long give the Tunisian ores a chance of competing on the world's markets.

The easternmost deposits of the Nefzas territory (Tamera, Ganara, Burshiba) are barely 62 miles from the great harbour of Bizerta, which now admits vessels of any tonnage, and the steam-colliers which generally return to the British coast in ballast, would no doubt load these ores at cheap freights. The author thinks that in that event, colliers finding on the spot a return cargo, Bizerta would soon rival Malta and Algiers as a coaling-station. The cost of the iron-ore at the mine, got by opencast working, would not exceed 2s. per metric ton, and it is calculated that the ore could be delivered at Bizerta, when the projected railway is built, at the price of 8s. 4d. per metric ton.

L. L. B.

MANGANESE ORES OF BRAZIL.

Les Manganèses du Brézil. *By* MIGUEL RIBEIRO LISBOA. *Revue Universelle des Mines*, 1898, *vol. xliv.*, *pages* 1-22, *with* 1 *plate.*

Manganese-ores occur in the provinces of Matto Grosso, São Paulo and Minas Geraes. In the latter province, workings are prosecuted at Queluz and Miguel Burnier, about 320 miles from Rio de Janeiro.

The ore consists of manganite ($Mn_2O_3H_2O$), with some pyrolusite (MnO_2), and other oxidized minerals, containing from 50 to 54 per cent. of manganese and 15 per cent. of volatile matter. The ore is found in thin veins in the crystalline schists of Queluz and Gaudarela, and in considerable masses in the older stratified (Huronian) rocks, which are chiefly itabirite, a slaty rock made up of specular iron-ore and quartz, overlying limestone. The ore-masses, from 6 to 7 feet in thickness, are contained in the itabirite, and follow the undulations of the strata. The dips vary from 30 degrees to vertical, and extend for some miles. The ore is worked in quarries by hand-tools, without explosives.

M. W. B.

GEOLOGY OF THE KLONDIKE GOLD-FIELDS, CANADA.

Die geologischen Verhältnisse der Goldlagerstätten des Klondikegebietes. *By* DR. OTTO NORDENSKJÖLD. *Zeitschrift für Praktische Geologie*, 1899, *pages* 71-83, *with a map in the text.*

The author made a stay of several months in the Klondike district in 1898, with the view of reporting on its capabilities to a group of Swedish capitalists who had sent him out there. He gives, in the first place, a brief topographical description of the area, and shows that practically all the streams carry gold. Viewed as a whole, the district is a plateau, lying at about 3,000 feet above sea-level, wherein the rivers have carved out valleys from 1,000 to 2,000 feet deep. These valleys, however, do not possess the character of cañons: terraces range along the Yukon, and at the junction of the Eldorado and Bonanza creeks rise 200 to 300 feet above the stream. These terraces are mostly gold-bearing.

It would appear that neither Mr. Spurr's description of the rocks in the neighbouring American territory, nor Messrs. Dawson, McConnel and Russell's careful studies of the Upper Yukon (Fort Selkirk and Porcupine River districts) can be extended by analogy to the Klondike district proper: in these regions the rock-succession varies greatly from place to place.

Round about Dawson City the hills are made up of decomposed diabases, actinolite-rocks and chlorite-schists, interbedded almost horizontally with graphite and granulitic schists. Among these occur crush-zones, characterized by friction-breccias, in which here and there gold has been found. Such are the rocks which predominate for about 12 miles along the Klondike river, but southward of this, along the Bonanza, Hunker and Sulphur Creeks, etc., stretches a vast area of fairly uniform, more or less intensely folded and crushed mica-schist, abundantly felspathic. In this area, the richest finds of gold have been made, and the author designates the mica-schist as the "Eldorado type." Between the Klondike and Indian rivers, and for some distance south of the latter, the outcrops are mainly biotite-gneisses; but in the region of the Stewart river there is an endless alternation of hälleflintas, chlorite-, biotite- and hornblende-schists with thin bands of limestone, etc. Between Dominion and Australia creeks, the hills are made up of a massive, finely crystalline, light pink granite. All the rocks that have just been enumerated are traversed by veins of varying character, some of which are connected with the original

mountain-folding, whereas others are of a later date. In the central gold-field thick veins of pure white, hungry quartz are extremely common, but they have proved quite barren of gold so far. In the peripheral portions of the Klondike district, on the other hand, quartz-veins seldom occur, but eruptive vein-rocks such as porphyrites, syenites, etc., are much more frequent. Porphyritic granite-veins are abundant in the Stewart river district: in these the author failed to observe any gold or even pyrites.

It is said that coal crops out in the Upper Klondike valley, below the mouth of Flat creek: the author believes it to be a freshwater formation of Cretaceous or Eocene age. The valleys were cut down to their present depth during late Pliocene or early Pleistocene times. Even before that, slow weathering of the surface-rocks began on an extensive scale, and has continued ever since. From that period date the richest gold-placers. The deeper layers of old gravel are frozen into a mass which is never reached by summer thaws, and so they have remained in place just as if they had been cemented into a true conglomerate. The very existence all over this region of the deep crust of weathered rock proves that it was at no time covered by an ice-cap: there were, at most, some small, quite local glaciers at the head of the valleys.

Only in the peripheral portions of the Klondike district has gold been found as a primary deposit, that is, occurring in matrix-rock which is *in situ*. Near Dawson City, for instance, gold is found in small quantities in nests of quartz in a great belt of breccias in the greenstone-formation.

The richest gold-bearing creeks in the area are the Eldorado, Bonanza, Hunker, Dominion, Sulphur Bear, All Gold and Quartz creeks, with their several tributaries: none of them are large streams. The author, in his description of the placers, selects the Eldorado creek as typical. The old alluvia, consisting of gravels with a little sand, are, as one might expect, thicker and their pebbles more rounded the lower down the valleys that they are struck. The materials of which they are made up are mostly the rocks that now come to-day in the immediate neighbourhood. The gold occurs in grains and nuggets of all sizes and shapes, though not as a rule very much rounded, in a long strip of gravel about 120 feet broad and 1 to 2 feet thick, which follows closely the decomposed bed-rock. The latter is itself rich in gold, and is often successfully worked to a depth of 8 or 10 feet: moreover, on either side of the richest portions of the gravel-strip much gold is found in the bed-rock across the entire breadth of the valley. The upper layers of the gravel contain little or no gold, and the same remark applies to the recent river-deposits. Remains of mammoth and other extinct mammals occur in association with the precious metal. The terrace-deposits or bench-claims are most extensively developed along the Bonanza creek; most of them lie only a few feet higher than the present valley-bottom, and some of them are as rich as the best creek-claims.

The frequent occurrence of quartz-fragments in association with the gold-grains points (in the author's opinion) to the original connexion of the precious metal with the eruption of acidic magmas, which evidently accompanied the processes of mountain folding. The pale mica which is also associated with the gold and is characteristic of the neighbouring rocks, is probably due to solfataric phenomena as much as to dynamo-metamorphism.

The author describes the rather primitive methods by which the placers have been worked hitherto, and points out that the mineral wealth of the district surpasses that of any known gold-field in British Columbia or Eastern Siberia. He estimates that during the next 4 or 5 years it will yield annually from £2,000,000 to £3,000,000, and thinks that further discoveries of gold, over and beyond the area already known, may be looked for. L. L. B.

GOLD-MEASURES OF NOVA SCOTIA.

The Gold-measures of Nova Scotia and Deep Mining. By E. R. FARIBAULT. *The Journal of the Canadian Mining Institute,* 1899, *vol. ii., pages* 119-129, *and* 5 *plates.*

Since the gold-measures of Nova Scotia became known, about the year 1860, it has gradually become evident that the workable deposits of free gold are confined to the metamorphic rocks of the Atlantic coast, along which they form a continuous belt from one end of the province to the other, a distance of some 260 miles, varying in width from 10 to 75 miles. Although no well-defined fossils have so far been found in the sedimentary rocks constituting the gold-measures, most geologists agree to classify them, provisionally, as Lower Cambrian. The measures fall into two well-defined groups, viz., a lower or "quartzite-group," and an upper or "slate-group." The Geological Survey places the thickness of the quartzite-group, as far as denudation has exposed these rocks to view, at about 3 miles, and the thickness of the slate-group at about 2 miles. The beds of quartzite and slate forming the gold-measures were originally deposited horizontally, but they have been bent and folded (roughly parallel with the sea-coast) to such a degree that they occupy only one-half of their former width, measured at right angles to the strike. Extensive denudation has worn away the measures to their present level. Some of the sharpest and highest folds have been truncated to a depth of over 8 miles, exposing at the surface a section of gold-measures over 5 miles thick.

The most important feature disclosed is that all the rich veins, and the large bodies of low-grade quartz worked in Nova Scotia, with few exceptions, follow the lines of stratification, and occur at well-defined points along the anticlinal axes of the folds. In order to locate the auriferous quartz-deposits on the surface, and to develop them in depth, a thorough knowledge of the structure of the anticlinal folds is necessary. The rocks, on opposite sides of anticlinal axes, generally dip at angles of between 45 and 90 degrees, seldom less than 40 degrees, and overturned dips are frequently found.

When the pitch inclines both ways from a central point, that point is the centre of an elliptical dome, and marks the position of one of the most favourable points on the main anticlines for the occurrence of quartz-veins. The average distance between one dome and the next along the same anticlinal axis varies from 10 to 25 miles. Most, if not all, of the gold-mining centres operated are situated on these domes. The quartz-veins are sometimes very numerous on both sides of the anticlinal domes. On the Goldenville anticlinal dome, some 55 different veins have been worked, or uncovered. In many cases, they extend on the surface for thousands of feet, and have been mined to depths of 700 feet in their vertical extension. The thickness of the veins varies considerably. The saddle reef-deposits are by far the largest bodies, those worked at Salmon river and other places attaining 15 to 25 feet in thickness. The veins along the legs of the folds are much smaller, averaging from 4 inches to 1 foot, but often thicker. Many quartz-veins are also found cutting the stratification at various angles; some are of great thickness; many are auriferous, and a few have been operated with notable profit.

In the interstratified veins, the gold is sometimes distributed uniformly over considerable areas; usually, however, it is more or less concentrated within certain limits, leaving spaces on each side comparatively barren. These enrichments are known as pay-streaks. Most pay-streaks are well-defined enrichments of 20 to 26 feet in breadth, often accompanied by enlargement

in the size of the vein. They dip at low constant angles, and are approximately parallel with the anticlinal axis. Many of the pay-streaks have proved very rich; some have been traced from the surface along a gentle incline for 1,800 feet, and, in many instances, three pay-streaks have been determined in the same vein, lying parallel under one another for some distance. The laws governing the position and extent of the pay-streak are intimately connected with the structure of the anticlinal folds; and the partially solved problem of these laws only needs complete solution by mining engineers in order to place the Nova Scotia gold-field among the most productive in the world. A principal aid to this complete solution would be furnished by the systematic preservation and comparison of the various mine-plans. The author also gives several diagrams and geological sections of the neighbourhood, and advances theories of the geological history of the Nova Scotian gold-bearing strata.

X. Y. Z.

COPPER-ORE DEPOSITS IN LOWER CALIFORNIA, MEXICO.

Ueber eine Kupfererzlagerstätte in Nieder-Californien. *By* P. KRUSCH. *Zeitschrift für Praktische Geologie*, 1899, *pages* 83-86.

The deposit with which the author is chiefly concerned is in the neighbourhood of the celebrated Boleo mines, and occurs 2 miles from the eastern coast of the peninsula, in latitude 27 degrees 30 minutes north, about 63 miles north-north-west of the small town of Mulege. The region is one of Tertiary volcanoes and volcanic sedimentaries: trachyte-cones range in a double chain, parallel with the coast-line, across the tuff-agglomerate plateau. Later than these acid trachytes are the basalt-sheets which in part cloak the acid rocks and overflow on to the plateau. Fossiliferous limestone-bands interstratified with the tuffs show these to be of Miocene or Lower Pliocene age.

The metalliferous ores appear to occur as veins in the sedimentaries, and although they are got at depths of 100 feet or so below-ground, they are in the main decomposition-products. The author examined the ores microscopically and made chemical analyses of them, and he describes in detail the results of this study. He shows that the primary ores, consisting essentially of chalcopyrite and copper-glance, associated with chalcedony, are present in comparatively small amount. The major portion of the ores was transformed into carbonates (malachite, azurite) by waters carrying carbonic acid in solution, but some portion of the copper recombined with the sulphur thus set free. Later on, thermal waters with silicic acid in solution came in, and the reactions thus set up produced black copper-ore, opal, native sulphur and gypsum. The hypothesis that thermal waters were largely concerned in the genesis of the ores as we now find them is the more probable that the district was for a long period the scene of volcanic activity. Another point to be noted in connexion with the deposit described by the author is the triple association of copper, manganese and cobalt, unique in Lower California. The association of copper and manganese alone is characteristic of many deposits in that area, but in some cases manganese is the more abundant ore of the two, while copper plays merely an accessory part.

L. L. B.

NATURAL COKE IN THE SANTA CLARA COAL-FIELD, MEXICO.

Natürlicher Koks in den Santa Clara-Kohlenfeldern, Sonora, Mexiko. By Dr. CARL OCHSENIUS. *Zeitschrift für Praktische Geologie*, 1900, *page* 21.

The coal-measures of Santa Clara, Sonora, are underlain by igneous rocks: they are much disturbed, broken through, and overlain by eruptives and intrusives of various ages. The coal-seams are interbanded with sands and clays, and the first discovery of a small seam of impure natural coke was made at Calera Creek. Later on, several other coke-beds were discovered, each 8 to 10 feet thick, regularly bedded and extending over considerable distances. They are generally, as might be expected, associated with eruptive rocks, which either form the roof or floor, saving the interposition of a thin band of shale. Sometimes the eruptive rock and the coke are found intimately intermixed, and in other cases the former fills small fissures in the latter. Nevertheless, the coke does not appear to have originated solely from contact with the eruptive rock, for pockets of coke occur in 4 feet anthracite-seams; or coke and coal lie next one to the other in the same bed, separated by 3 inches of clay. Graphite occurs on fractured surfaces of the natural coke, and sometimes the anthracite is seen to pass into graphite. This would tend to prove that vegetable tissues are metamorphosed into graphite by passing either through the phase of anthracite or through the phase of natural coke. The natural coke is dark-grey, minutely porous, and more compact than oven-coke. It possesses the same fibrous structure as the latter, makes an excellent fuel, leaving a white ash, and is not more difficult of ignition than anthracite. Further particulars will be gleaned from the *Chemiker Zeitung* (1899), and from Mr. E. T. Dumble's paper.*

The present author regards this discovery of natural coke as an important confirmation of his view that graphite is the final term of the series beginning with peat, and passing through lignite, coal, anthracite and coke, and is therefore undoubtedly of organic origin.

L. L. B.

CALIFORNIA ASPHALTUM.

California Asphaltum: a Description of Some of the Principal Deposits and the Methods of Refining and Handling the Mineral. By PROF. ARTHUR LAKES. *Mines and Minerals*, 1899, *vol. xx.*, *pages* 108-109, *with* 4 *figures in the text.*

Of the great deposits of Santa Barbara county, those used for paving belong to the Alcatraz Asphalt Company, of San Francisco, whose properties in this county extend to 35,000 acres. They have large refining works at Carpinteria, where they extract the bitumen from the large deposits of bituminized sands on the seashore. The product is of high grade, running over 98 per cent. pure. They also operate underground mines to the west of Santa Barbara.

On what is known as the Sisquoc Grant, in the northern part of the county, occurs the Mesa deposit, located upon a plateau 1,900 feet above sea-level and 25 miles from the coast. This plateau is a spur of the main mountain-range, surrounded on three sides by valleys 250 to 500 feet in depth, where the surface has been eroded, the deposit remaining in place through the cementing quality of the bitumen. The deposit is exposed to the surface in some parts,

* *Transactions of the American Institute of Mining Engineers*, 1899, vol. xxix., page .

and overlain by 2 to 3 feet of earth in others. It is over 1 mile long, ¼ mile wide, and nowhere less than 125 feet deep. It contains between 20,000,000 and 30,000,000 tons of crude material and between 4,000,000 and 5,000,000 tons of pure bitumen. Here the Alcatraz Company has large separation-works, which separate the bitumen from the sand, throwing away the sand, perfectly clean, into the valleys below. As the process involves the use of solvents, the bitumen is liquefied sufficiently to flow through pipes and is thus transported by gravity nearly 30 miles to the finishing-works on the Santa Barbara Channel. The bitumen arrives at Alcatraz Landing in the form of a fluid solution, from which the solvent is quickly separated under low temperature, leaving the bitumen in its natural state, nearly 100 per cent. pure, ready for market. It undergoes no other process. After separation from the bitumen, the solvent is pumped back to the separation-works at the mine by a system, which is a model of ingenuity and mechanical perfection. The output per annum is about 50,000 tons of practically pure bitumen.

X. Y. Z.

THE GRAND RIVER COAL-FIELD OF COLORADO.

The Grand River Coal-field of Colorado. By Arthur Lakes. *Mines and Minerals*, 1899, *vol. xx., pages* 110-111, *with* 3 *figures in the text.*

One of the largest and most interesting of the great coal-fields of Colorado is the Grand River field, not only for its numerous and large coal-seams, but for the varied character of the coal, and the peculiar geological conditions which produced these varieties. These conditions are intimately connected with the degrees of heat developed by the extraordinary volcanic or eruptive activities to which the entire region has been subjected. The eruptive phenomena which have so affected this region are of that peculiar class known as laccolitic. Huge bodies of molten rock, rising from below, and failing to break through to the surface, pushed thick intrusive sheets between the layers of sedimentary strata, raising them up into hollow arches, and filling the space with molten lava. Subsequent extensive erosion has exposed the underlying mountain-mass of lava, with the sedimentary strata dipping off from it on all sides. Cretaceous shales are changed into crystalline roofing-slates; sandstones into hard quartzites; and, locally, Silurian and Carboniferous limestones are altered into some of the finest white and variegated marbles and serpentines to be found on this continent. The effects of greater economic importance are those on the coal-beds, which here attain an extraordinary thickness and number of seams. As the coal approaches the centres of volcanic force, there is a gradual transition, first from bituminous to coking coal, then to semi-anthracite, and finally, at close contact with the eruptive rock, to true lustrous anthracite.

The Grand River coal-region is on the west of the Colorado range, and is drained by the Grand river. The coal-field is a portion of a larger field extending through eastern Utah to the base of the Wahsatch mountains. The area is interrupted here and there by the intrusive laccolites, such as the series passing along the base of the Ragged mountains. The thickness of the Laramie coal-bearing strata on the western side of this range is from 2,000 to 3,000 feet—much greater than the thickness on the eastern slope. In the eastern portion of the field, there are 4 to 5 main workable seams; in the central part, there are 7 or more. The coal varies from bituminous to true anthracite, according to distance from the main eruptive centres. In the Grand River

district, the coals are located along a very lofty hogback, as at Newcastle and Coal Ridge. The dip is from 57 to 60 degrees for the lower and from 25 to 40 degrees for the upper seams. There are 7 workable seams, the aggregate thickness of clean coal exceeding that found in any other portion of Colorado. In a thickness of 1,000 feet of strata are found 105 feet of clean coal of a semicoking and domestic kind, viz., one 4 feet seam, two 5 feet seams, one 8 feet seam, and three thick seams of 18, 20 and 45 feet respectively.

X. Y. Z.

SNAKE RIVER GOLD-FIELDS, IDAHO.

The Snake River Gold-fields of Idaho. By DON MAGUIRE. *Mines and Minerals*, 1899, *vol. xx., pages* 56-58, *with* 1 *illustration.*

Snake River valley, exclusive of mountain-spurs, contains about 37,500 square miles. The lava-fields that cover a vast area of the Snake River country may, from the evidence of the fossils found underneath, be assigned to the later Tertiary or the early Quaternary period. The metallic values found in the Snake River country consist almost wholly of the gold found in the sands of the streams. The writer estimates the approximate value of the Snake River gold-placers at not less than £400,000,000. The source of the gold seems to be the Caribou, Snake River and Pierre's Hole mountains, whose waters flow entirely into the southern fork of Snake River. It is an extremely fine flour-gold, so infinitesimally small that each particle of it will float in a moderately rapid current. So far, the primitive methods of obtaining gold have here paid best, the method most successful in Snake River gold-mining being that known as the "burlap process." This is a simple and inexpensive method, and Snake River valley has well been termed the "poor man's mining country," inasmuch as the miner can always make a living, but rarely more than a living. Very expensive machinery has from time to time been prepared for saving the fine gold on this river, but has never produced adequate returns. X. Y. Z.

THE CUPRIFEROUS DEPOSITS OF MANDOR, WESTERN BORNEO.

Het Voorkomen van Koperertsen in den Omtrek van Mandor. By N. WING EASTON. *Jaarboek van het Mijnwezen in Nederlandsch Oost-Indië*, 1899, *vol. xxviii., pages* 143-167, *with* 2 *plates (map and sections).*

In 1858-1861, some prospecting was done in the Mandor district by Mr. R. Everwijn, and the results of his researches were published in the *Jaarboek* for 1878. He opined that the copper-ores which he traced in no less than 24 localities would not repay working, and his views are fully confirmed by the present author, after careful investigation. The following is a summary of the main facts upon which these conclusions are based.

Copper ores, associated here and there with small quantities of galena and zinc-blende, and always accompanied by iron-pyrites, are very widely distributed in the granite, which is the basement-rock, upon which rest the younger sandstones and shales. This distribution is restricted to the uppermost portions of the granite, especially where the rock has undergone much weathering. On the other hand, copper-ores occur only exceptionally in the sandstones and shales, these sedimentaries being, however, extensively impregnated with iron-ore or containing it in the form of fissure-deposits. There are no

cupriferous "main leaders," but rather infillings of thin cracks or clefts, which in places broaden out and strike generally east and west, or north-east and south-west, and pitch steeply eastward. There is no likelihood whatever that these cupriferous deposits will prove to be of economic value.

L. L. B.

THE ORIGIN OF THE BROKEN HILL ORE-DEPOSITS, NEW SOUTH WALES.

Beiträge zur Kenntniss von Brokenhill. By R. BECK. *Zeitschrift für Praktische Geologie*, 1899, *pages* 65-71, *with 5 figures in the text.*

The author points out that, despite the exhaustive memoirs of Mr. E. F. Pittman and Mr. J. B. Jaquet, on Broken Hill, there still remained untouched certain points which are of great importance in regard to the genesis of the ore-deposits. Having at his disposal a large mass of material, he examined microscopically the country-rock. This is predominantly a garnetiferous gneiss, with which garnetiferous quartzite is frequently interbedded: both rocks contain fine scales of sericite, the presence and habit of which point to dynamo-metamorphism. With regard to the ores themselves, the author leaves aside those of the upper levels, the latest in date of formation, and limits himself to the consideration of the sulphides. These are chiefly argentiferous galena and blende, intimately associated with a peculiar grey-blue quartz, garnet, rhodonite and fluorspar (the last-named being generally invisible to the unaided eye). The ubiquitous presence of garnet is noteworthy: it occurs, first, both macroscopically and microscopically as a sort of breccia of angular fragments enveloped by the metalliferous ores; and, secondly, in idiomorphic crystals, evidently of fresh growth, amid the mass of ores, and containing inclusions of the ores. Rhodonite is not so universally distributed in the ore-body as garnet: the salient fact in the author's detailed description of its occurrence is the corrosion of the rhodonite by the solutions which brought in the ores. The blue quartz often exhibits a mosaic structure, and is bespattered with fissured garnets, the fractures being infilled with galena. All this points to dynamic phenomena resulting in various chemical reactions and recrystallization.

The author then describes the structure of the salbands, and shows that his observations confirm the hypothesis formed by Messrs. Pittman and Jaquet as to the manner in which the great Broken Hill deposit was formed. It is essentially the result of foliation on a grand scale in the overfold of a "saddle" in the gneiss: an irregular hollow was torn in the rocks, the walls of which broke away, the hollow being in part filled with crumbled rock-débris, and then completely filled by the inflow of metalliferous ores with fluorspar, secondary garnet, etc. In fine, the author ranks the Broken Hill ore in the category of vein-deposits, rather than in that of true bedded deposits. He thinks that it forms a type of itself, so far unique.

L. L. B.

QUARTZ REEFS OF THE HILL END AND TAMBAROORA DISTRICT, NEW SOUTH WALES.

By J. ALEX. WATT. *Annual Report of the Department of Mines and Agriculture, New South Wales*, 1898, *pages* 9 *and* 172-177, *with plans and sections.*

The Prospecting Board proposed to put down some bore-holes to test Mr. Watt's theory as to the occurrence of a saddle-reef formation at Hargraves and Hill End, somewhat similar to that worked at Bendigo, in Victoria. The

author was directed to visit Hill End and advise as to the best way of sinking for the lost reefs. Particular attention was directed to ascertaining the mode of occurrence and probable origin of the gold-bearing quartz-reefs. It had been shown that in the case of the Hargraves district (about 20 miles from Hill End), the movements to which the rocks there had been subjected have resulted in the production of saddle-shaped cavities between the strata, which have later become filled with auriferous quartz by the infiltration of mineral-bearing solutions. In this way, reefs have been produced which resemble in all their essential features the famous saddle-reefs of Bendigo. Before the examination of the Hill End gold-field had proceeded far, it became clear that the phenomena of the Hargraves saddle-reefs were there reproduced as far as the general facts of the mode of occurrence and origin were concerned, though there are some important differences.

After describing the nature of the rocks and the mode of occurrence of the reefs, the author states that taking these into account, together with the close resemblance of the general features of the district to those of Hargraves, where saddle-reefs had been proved to exist one under the other, it was extremely probable that the Hill End reefs, as now exposed at the surface, were principally the denuded east-and-west legs of saddle-reefs which at one time were continuous across the centre of the arch. Further, the gently curving or flat lying masses of quartz situated between the two series of reefs appeared to be the caps of saddle-reefs, which owed their appearance at the surface to the denudation of an immense thickness of rocks, comprising slates, sills, and the caps of overlying saddle-reefs. It was this process of denudation that had supplied the gullies with the enormous quantity of alluvial gold which had been obtained from them. The sources from which the gold was derived were in all probability, those portions of the saddle-reefs which had disappeared in this process, leaving the easterly and westerly dipping reefs as mere remnants of them. If this theory furnishes the correct explanation of the phenomena presented by the Hill End reefs, the following conclusions may be legitimately drawn from it:—

(1) The easterly and westerly-dipping reefs will decrease in size as they are followed down, until they finally pinch out altogether. This fact is even now to some extent recognized, for some of the reefs have already disappeared, or become greatly reduced in size in the deeper workings. Some, however, have already been proved to a depth of 800 feet from their outcrops without showing any appreciable diminution. This very important feature distinguishes these legs from reefs of a similar character at Bendigo, where, as a rule, they cut out at 100 feet below the saddle, and only exceptionally extend downwards 700 or 800 feet from it. This feature is not remarkable when we keep in mind the great breadth of the Hill End arch as compared with Bendigo, and should have an important influence favourable to Hill End, on the relative persistence in depth of the saddle-reefs of the two places.

(2) Saddle-reefs will be found, of which there are now no traces whatever on the surface, but which will make their appearance one under the other as the prospecting operations are conducted downward in the neighbourhood of the centre of the arch. It is only reasonable to suppose that, as the circumstances are so similar at Hill End and Bendigo, and as at Bendigo they have been proved to a depth of at least 3,350 feet from the surface, they will also be found to extend to a considerable depth at Hill End.

(3) Other arches containing saddle-reefs will be found to the east and west of Hill End, *i.e.*, in parallel folds of strata. The author, in fact, suggests that such reefs have already been worked at Stuart Town on the west and at Sally's Flat on the east without their true nature being quite understood.

The author claims that this theory (which the Prospecting Board had already decided to test) satisfactorily explains all the observed phenomena, and he thinks that the possibilities of the future of the district can hardly be exaggerated. He points out that the pioneers of reefing at Bendigo had to face the same problems as those now presented by the Hill End gold-field, and that it was not until they had solved these and proved the existence of saddle-reefs recurring one under the other that the permanence of that field was established. X. Y. Z.

DECOMPOSITION OF CARBON MONOXIDE IN PRESENCE OF METALLIC OXIDES.

(1) *Sur la Décomposition de l'Oxyde de Carbone en présence de l'Oxyde de Fer.* By O. Boudouard. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, 1899, *vol. cxxviii.*, *pages* 98-101.

The experiments were performed at a temperature of 445° Cent. with varying quantities of iron oxide and durations of exposure to the carbon monoxide. The latter—containing 95 to 97 per cent. of carbon monoxide—was produced by acting on sodium formate with sulphuric acid, and purified from carbon dioxide by passage through potash and baryta-water. The iron oxide was prepared in an extremely fine state of division by calcining pumice-stone steeped in ferric-nitrate solution, and was then placed in glass tubes drawn out fine at both ends, and heated in a sulphur-bath, through which tubes the carbon monoxide was passed until the complete reduction of the iron occurred and a deposit of carbon formed: the contents being analysed after the tubes had been left, sealed up, in the sulphur-bath for some time longer.

The results obtained were as follows:—

Time in Minutes.	8		40		64		80		180		360		420	
Weight of Iron Oxide	CO_2	CO	CO_2	CO	CO_2	CO	CO_2	CO	CO_2	CO	CO_2	CO	CO_2	CO
Grammes. 0·0673	30·2	69·8	57·4	42·6	..	..	87·0	13·0	94·8	5·2	100	..	..	..
0·0224	16·1	83·9	..	..	62·9	37·1	..	..	..	..	..	..	100	..
0·0023	2·9	97·1	..		36·6	63·4	..	..	..	..	52·3	47·7	..	..

The results show that the decomposition of the carbon monoxide depends on the time-factor and quantity of iron oxide present, the quantity of carbon dioxide formed increasing with regularity. C. S.

(2) *Sur la Décomposition de l'Oxyde de Carbone en présence des Oxydes Métalliques.* By O. Boudouard. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, 1899, *vol. cxxviii.*, *pages* 307-309.

In carrying his experiments further, the author finds that results similar to those yielded by iron oxide are furnished by other oxides. In the case of nickel and cobalt, the time required for the complete conversion of carbon monoxide into dioxide is 8 minutes when 0·15 gramme of nickel or cobalt oxide is used, increasing to 60 minutes and 255 minutes with 0·05 and 0·005

gramme respectively. On substituting wood-charcoal for pumice, as a carrier of the metallic oxide, the results obtained were similar, though a longer exposure to heat was found necessary, in order to complete the decomposition of the carbon monoxide. C. S.

WITKOWITZ COLLIERIES IN DOMBRAU, AUSTRIA.

Die Anlagen der Witkowitzer Steinkohlengruben in Dombrau. By DR. AUGUST FILLUNGER. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1899, *vol. xlvii., pages* 473-475, 487-489, 499-502, *and* 4 *plates*.

The coal-field is worked by means of four shafts, the Bettina and Eleonora, which are the older, and two newer shafts.

The following are some data with regard to the sinking of the Eleonora winding-shaft. The area inside the walling was 237 square feet or 22 square metres. The depth sunk from April, 1893, to January, 1896, was 1,981 feet or 604 metres. The cost of sinking was :—

	Per Metre. Florins.	Per Foot. £ s. d.
Wages	270·85	8 5 2
Materials	169 74	5 3 6
Totals ...	440·59	£13 8 8

The cost of walling the Eleonora shaft from April, 1894, to August, 1897, for a length of 1,611 feet or 491 metres was :—

	Per Metre. Florins.	Per Foot. £ s. d.
Wages	126·49	3 17 1
Materials	243·50	7 8 6
Totals ..	369·99	£11 5 7

The total cost of the shaft in working order was :—

	Per Metre. Florins.	Per Foot. £ s. d.
Wages	397·34	12 2 3
Materials	413·24	12 12 0
Totals ...	810·58	£24 14 3

The No. 2 air-shaft had an area inside the walling of 171 square feet or 15·89 square metres. The depth sunk from May, 1898, to January 31st, 1899, was 413 feet or 126 metres. The cost of sinking and walling was :—

	Per Metre. Florins.	Per Foot. £ s. d.
Wages	144·76	4 8 3
Materials	146·89	4 9 7
Totals ...	291·65	£8 17 10

Each of the two winding-shafts is laid out for two sets of cages, double-decked cages, taking 2 tubs end to end, and small cages for one tub. Accordingly, at each lift, 5 tubs can be wound, carrying 8 cwts. of coal, so that in both shafts 40 cwts. can be raised per lift.

The dressing-plant is arranged to treat 1,400 tons in 10 working hours. It is erected between the two shafts, 558 feet (170 metres) from the Eleonora shaft and 820 feet (250 metres) from the Bettina shaft, with which it is connected by means of an iron gantry. The coal is conveyed to the dressing-plant by means of chain-haulage, driven by an electric motor. Each dressing-plant consists of a friction-driven cylindrical tippler, a Karop screen, and a Klonne gyrating-screen, by means of which lump, nut and small coal can be made. The Klonne screen produces a considerable amount of fine dust, to remove which an exhaust-fan has been erected, which carries the dust-laden air through a series of dust-chambers, in which it is deposited. This dust has a very high calorific value, and on account of its fine state of division is especially useful for employment under dust-fired boilers, for which purpose it is drawn off from the dust-chambers and collected in sacks.

Electrical transmission is largely used at these mines, the plant consisting of 3 dynamos, each of 250 horsepower, and 10 motors of 5 to 180 horsepower each. The motor is a compound-wound continuous current machine, giving 170 kilowatts at a tension of 550 volts. Among other applications, a motor is employed for underground pumping, lifting 2·64 gallons (12 litres) of water to a height of 1,532 feet (467 metres) at 70 revolutions per minute by means of a triplex differential plunger-pump. The air-chamber is filled by means of a two stage air-compressor. The motor that works the pump has an efficiency of 180 horsepower at a tension of 500 volts, making 400 revolutions per minute.

In order to obtain suitable water for the boilers, two pumps have been erected at the Olza river, 10,710 feet (3,265 metres) distant from the central electrical station, by means of which water is pumped to a high-level reservoir erected near the Eleonora shaft. The two pumps can deliver respectively 330 and 528 gallons (1,500 and 2,400 litres) of water per minute.

For the sinking of the No. 2 shaft, a hoist and a sinking-pump are employed, worked electrically. The hoist is calculated to lift 8 full tubs per hour from a maximum depth of 1,640 feet (500 metres). Whenever, by any accident, the cage rises 3 feet (1 metre) above the shaft-collar, an indicator of the usual type touches a contact and thus closes a circuit, by means of which two electro-magnets are brought into play which actuate a very powerful brake and automatically cut out the motor.

The sinking-pump consists of three plunger-pumps, which force 22 gallons (100 litres) per minute to a height of 394 feet (120 metres). The pump is worked by a 6 horsepower motor, which is enclosed in sheet-iron, and carried, together with the pump, upon an iron frame, so that the pump and motor can be raised and lowered in wooden guides. H. L.

COAL-MINING IN BOSNIA.

Mittheilungen über den Kohlenbergbau in Bosnien. By OBERBERGRATH F. POECH. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1899, *vol. xlvii., pages* 369-373, *and* 1 *plate.*

Since coal-mining commenced in Bosnia and Herzgovina, in 1880, it has undergone rapid developments, as is shown by the following table :—

Year.	Production.	Number of Workmen.
	Tons.	
1880	499	16
1885	23,009	143
1890	59,342	215
1895	195,441	750
1898	268,700	830

Although the production is small compared with those of the larger works of the Austrian Empire, it must be borne in mind that the coal-mines of Herzgovina command but a small area within which their product can be distributed.

Zenica Colliery.—The Zenica-Sarajevo coal-basin contains, in the neighbourhood of Zenica, four coal-seams, three of which are workable, with respective thicknesses of 31, 13 and 24 feet (9·5, 4 and 7·3 metres). Allowing for the numerous calcareous partings, the thickness of clean coal in these seams may be taken at 23½, 10 and 13 feet (7·2, 3 and 4 metres) respectively, or 46½ feet (14·2 metres) in all. The seams extend in the direction of their strike towards the south-east for a length of about 25 miles (40 kilometres), whilst towards their dip they also appear to cover a very considerable area. The coal is bituminous, of Oligocene or Miocene age. The latest analyses show 4,600 to 5,000 calories, 6 to 10 per cent. of ash, and 2·6 per cent. of sulphur. There are numerous faults, some of which are small hitches, whilst others are serious dislocations. The area worked by the Zenica colliery is at present limited by large faults of the latter nature, the southernmost one throwing up the seams about 260 feet (80 metres).

In mining the coal, care has to be taken to get it as completely as possible, on account of the danger of gob-fires. It is stated that not more than 2 per cent. of the coal is lost in mining. Pit-fires are, however, by no means uncommon, and in order to be better able to battle with these, ventilation has been arranged so that it can be reversed, so as to work either by pressure or by suction, as required. The mine is ventilated by a Capell fan, 6½ feet (2 metres) in diameter, capable at 280 revolutions of exhausting 28,000 cubic feet (800 cubic metres) of air per minute, with a water-gauge of 1·8 inches (45 millimetres). The fan is placed so that its direction need never be reversed, and it can be transformed from a suction into a pressure-fan by simply altering the position of certain hinged doors.

Kreka Colliery.—Here, also, the existence of very large quantities of coal has been proved. The main seam contains 53 to 60 feet (16 to 18 metres) of pure coal, which increases in one of the pits to 79 feet (24 metres), in each case with numerous bands of stone. Attempts have recently been made to combat underground fires in this colliery by the introduction of liquid carbonic acid, which appears to have given satisfactory results up to the present, although the experiments upon it are not yet concluded. Ventilation is performed by means of a steam-jet and by an electrically driven Rateau fan, which has a guaranteed capacity of 14,000 cubic feet (400 cubic metres) of air per minute, with a water-gauge of 1·3 inches (33 millimetres) at 350 revolutions.

In addition, there are two small collieries owned by the State at Ugljevik and Banjaluka.

H. L.

IMPROVEMENTS IN MINING IN PRUSSIA DURING THE YEAR 1898.

Versuche und Verbesserungen beim Bergwerksbetriebe in Preussen während des Jahres 1898. ANON. *Zeitschrift für das Berg-, Hütten- und Salinenwesen im Preussischen Staate,* 1899, *vol. xlvii., pages* 173-224, *and* 4 *plates.*

Drilling.—The experiments at St. Andreasberg to determine what the minimum diameter of the cutting-edge of the drill used in machine-drilling should be, in order to secure the greatest efficiency, have been concluded. It was found that, with a depth of drill-hole of 6 feet (1·75 metres), the cutting-edge of the last drill should be 0·8 inch (20 millimetres), and the diameter of the dynamite cartridge 0·72 inch (18 millimetres). An economy in explosives was thus obtained, but it was found that further diminution was not profitable (1) because the drill steel was no longer sufficiently strong, and (2) because thinner cartridges were found not to be sufficiently effective.

Experiments were made at Clausthal to compare an electrically-driven percussion-drill of the Maroin pattern and a pneumatic machine-drill. The electric drill bored 4·8 feet (1·438 metres), and the pneumatic drill 6·4 feet (1·956 metres) per hour, so that the former was less efficient than the latter by 26 per cent. Strangely enough, however, a second experiment, in which an experimental drift was worked first for 8 double shifts with the electric drill and then for an equal time with the pneumatic drill, gave a contrary result. With the electric drill, the drift was advanced 9·8 feet (3 metres), and with the pneumatic drill only 8·5 feet (2·6 metres), in the same time. The experiments could not be concluded, as the electric drill then required repair. A definite decision could not therefore be arrived at, but it was found that the electric machine-drill, in its present form, could not be used everywhere with advantage in mining, as it was too long and too heavy.

An electric percussion drilling machine, made by Messrs. Siemens & Halske, was tried at the lead-and-zinc-mines of Glanzenberg. With 1 horse-power this machine was capable of drilling from 3¼ to 4 inches (8 to 10 centimetres) per minute in solid grauwacke, and up to 4¾ inches (12 centimetres) in grauwacke slates. Repairs are said to be very simple, and capable of being executed by any ordinary mine-smith.

Explosives.—In the König colliery, in Upper Silesia, exhaustive experiments were carried out with dahmenit A, by working a number of roads and pillars alternately for one month with powder and dahmenit. The results were so unfavourable to dahmenit, on the score of expense, that its further use had been abandoned. The additional cost of explosives came to 2·5d. (21 pfennigs) per ton in driving roads, and 1·2d. (10 pfennigs) in working pillars. The total costs were thus increased by 2·8d. and 1·8d. (23 and 15 pfennigs) respectively, whilst the production of round coal was notably smaller than when powder was used. It was shown in favour of dahmenit, when shots were fired, that the face was clearer of fumes than when powder was used. On the other hand, in the case of blown-out shots, nitrous-oxide gases were noticed to be very troublesome. This was especially the case when cartridges were used that had been stored for several weeks in the pit.

Walling of Shafts.—At the Göttelborn colliery, near Saarbrücken, the main shaft has been walled, not in the ordinary way with brickwork, but with concrete. This concrete consists of 1 part of cement, 3 parts of sand, and 6 parts of diorite, broken small. This mixture is moistened and stamped into the space between the excavated rock and a temporary lining consisting of iron rings 17·7 feet (5·4 metres) in diameter cased with wood, the depth of each layer of concrete being 6 inches (15 centimetres). The concrete is

rammed in and beaten down with iron stampers until it commences to sweat. The result was an excellent wall of very uniform strength.

Rateau Fan.—At the Consolidated Paulus-Hohenzollern colliery, an underground Rateau fan has been erected at the Gemander shaft. Its diameter is 7·87 feet (2·4 metres), and it is worked by a polyphase-motor of 32 horsepower, which receives its energy from a central station, situated some 1¼ miles from the shaft, by means of a special system of cables on the surface. At 180 to 190 revolutions per minute, this fan produces 65,000 cubic feet (1,850 cubic metres) of air with a positive water-gauge of 2·36 inches (60 millimetres). The airways are so constructed that by a very simple arrangement the direction of the ventilation can be rapidly reversed, which may be a considerable advantage in many cases, as, for instance, in the case of an underground fire, or of ice forming in the winding-shaft. H. L.

MINERAL INDUSTRY OF PERSIA.

Die Bodenschätze Persiens. By LUDWIG HENNECKE. *Zeitschrift für das Berg-, Hütten- und Salinenwesen im Preussischen Staate*, 1899, *vol. xlvii., pages* 272-274.

The apparent object of this paper is to call the attention of the author's countrymen to the splendid opportunities which the mineral wealth of Persia will afford, when the long-predicted, inevitable change in the political conditions of the country takes place. One of the chief obstacles to the development of mineral industry is the want of decent roads.

The mines of precious metals (turquoises, etc.) are State property, but the Government does not work them. Mining leases are granted for periods too short to attract serious enterprise. There is no timbering in the mines, nor is any suitable machinery brought into the interior of the country. Mining methods are, therefore, excessively primitive, and the annual output is incomparably smaller than it might be: the author reckons that only about £8,000 worth of precious stones is got every year in Persia.

In 1889 a British company, financed by the Imperial Bank of Persia, was started, to work the gold and other metalliferous mines, but the expectations then formed have not been fulfilled. Although rich ore-deposits were struck, the necessary fuel for smelting the ores could be obtained only at impracticable distances: the sea-coast is very far from the mines, and so too are the few coal-mines that exist in Persia. Gold occurs in the Bulmus Bash mountains, and at Meshed in the Turkebeh mountains: the placers are largely worked out, though in very primitive fashion. At Far Dáod, in the neighbourhood of Bosmishk, are copper-mines, now in part flooded, which are said to have yielded 11 parts per million of gold.

In the Senshan district, veins of pyritiferous quartz are found in granite, yielding 46 parts per million of silver. Argentiferous-galena veins course through mica-schist in the Arghun mountains, and the ore has yielded as much as 675 parts of silver in a million. The Arghun mines are worked by seven shafts, about 325 feet deep; little has been done in the way of providing proper supports, and falls of rock are frequent, not to speak of other accidents. Every year there are about 3 fatalities among the 110 to 125 miners employed. The anual output is very small.

Rich occurrences have been certified in many parts of Persia, of mercury, copper, tin, and antimony-ores, realgar, native sulphur, brown iron-ore, man-

ganese and cobalt-ores, kaolin, borax, and alum. Workable coal is found in the Elburz mountains, in the Sharud river-basin, and along the banks of the Kevech, while brown coal occurs near Tabriz. Petroleum is characteristic of the Tertiary deposits on the south-western border of the Persian Highlands; it is found, moreover, on the shores of the Persian Gulf, in the neighbourhood of the Dalaki river, in the Darab mountains, etc. Rock-salt also occurs in large quantities. L. L. B.

THE RAR-EL-MADEN MANGANIFEROUS IRON-MINE, ALGERIA.

(1) *Note sur la Mine de Fer Manganésifère de Rar-el-Maden, Province d'Oran. By* Ed. Dietz. *Revue Universelle des Mines*, 1899, *vol. xlvii., pages* 165-172.

(2) *Die Eisenerzgrube von Rar-el-Maden.* Anon. *Stahl und Eisen*, 1899, *pages* 669-672, *with* 4 *illustrations in text.*

The mine of Rar-el-Maden (hole of metal) is situated about 19 miles to the east of Nemours, 29 miles to the north-west of Tlemcen, and 5 miles (7½ kilometres) from the little port of Honaïne on the Mediterranean. On approaching the mine one encounters argillaceous shales, which form with the limestone rather high mountains, separated by valleys and deep gorges, in one of which latter occurs the Rar-el-Maden deposit.

The discovery of this mine was easy, because it is indicated by a fine cap of iron and a mass of old cinder, as rich as the ore itself, scattered over one of the sides of the gorge containing the deposit. Recent workings have revealed the place where the ancient Arabs worked a large quantity of the surface-ore; and the hole has since been filled up with sand and pebbles, washed down by the torrents. The ore projects from the abrupt slope of the gorge; and the very form of this deposit shows that a considèrable quantity of ore must have been removed by erosion, although that quantity is slight in comparison with what remains.

The origin of the deposit may be explained in all its phases by following the outcrops in one direction or the other. On the surface, it is lost in the form of small veins, which have practically the same bearing; but in some places, and towards the bottom, these veins become thicker, forming here and there small nests of ore, without, however, the limestone being coloured by the ferrous or ferric solutions. The ends of these veins often indicate the direction in which pockets should be sought; and following them leads to a point where they become more numerous and interlaced, so as to form a kind of *breccia* (this term not being used in its ordinary sense, because all the elements were formed *in situ*); and it may easily be seen that in one direction one of the elements becomes thicker while another diminishes. In the present case, the particles of iron-ore increase and those of limestone diminish as the outcrop is followed from top to bottom; and the converse is naturally the case when the ore is followed from bottom to top, where the compact limestone is reached. Here the ore is found to be enclosed in the limestone; but the bicarbonate solutions have not rendered complete the substitution of limestone for iron-ore.

The Rar-el-Maden deposit, occurring between the schist and the limestone, is a metamorphic contact-bed; and the iron is substituted for the limestone.

The author found, near the deposit, pieces of diabase or diorite, which are probably not connected with the origin of the ferruginous sources of the ore; and he is inclined to believe that carbonate of iron will be found in depth.

The upper layer of the deposit forms finely-divided ore, which is due to the shifting of the measures and also to atmospheric influence. The middle and lower portions are formed of partitioned ore (*minerai cloisónné*) and of masses in ribbon form, with concretions due to crystallization. These kidneys have a jet-black crust, probably very manganiferous, while the inside forms a crystallization sometimes fibrous and sometimes concentric.

One third of the ore is in fine grains, while the remaining two-thirds occur in pieces and in larger or smaller granulations, no doubt very easy to reduce, owing to the porosity and composition of the ore.

Working is effected opencast and in steps, and afterwards by drifts for obtaining a greater proportion of large ore. The composition is approximately:—Iron 50·5 per cent. and manganese 6·5 per cent. (making 57 per cent. of metal); phosphorous, 0·015 per cent.; sulphur, 0·025 per cent.; silica, 4 per cent.; lime and magnesia, 1 per cent.; and this excellent ore is, on account of its large proportion of manganese, suitable for producing *spiegeleisen* containing 12·5 per cent. of manganese.

The quantity of ore directly workable is estimated at 500,000 tons; but it is considered, owing to the method of formation, that other lenticular masses or pockets of ore are likely to be found, both in depth and direction, in contact with the schist and the limestone, as well as in the limestone itself, so that the Bar-el-Maden must be regarded among the important mines of rich ironstone.

The deposit is 170 feet wide, about 425 feet long, and about 200 feet deep. The iron-ore is conveyed from the mine to the shore by an aerial wire-ropeway, with a carrying capacity of about 20 tons per hour, loaded into lighters carrying from 10 to 14 tons, and then discharged into steamers lying off the shore.

J. W. P. and M. W. B.

THE DEVELOPMENT OF THE TRANSVAAL.

Du Développement du Transvaal et de son Industrie Minière. By G. BRAECKE. *Revue Universelle des Mines*, 1899, *vol. xlviii., pages* 105-138.

The author sketches briefly, from the Boer point of view, the political history of the Transvaal, upholding boldly the doctrine that the blacks were born to be slaves. Then, after a short description of the physiography and climate of the country, he turns to the oft-told tale of the gold-discoveries.

Previously to 1884, the only known auriferous deposits in the Transvaal were the alluvial placers of Lydenburg and De Kaap. In that year, however, true veins of auriferous quartz were struck in the nearly vertical Cambrian (?) metamorphic schists of the De Kaap Valley. The usual rush took place, the town of Barberton was founded, and for two years the district was the scene of abnormal mining activity, only to be deserted when over-speculation and downright fraud resulted in the inevitable *krach*. Then in 1886, the Messrs. Struben discovered the famous Witwatersrand bankets, consisting of rolled quartz-pebbles cemented together by auriferous iron-pyrites and grit. About half of the gold in the cement occurs in the metallic state, and is therefore capable of amalgamation, while the other half, being combined with the sulphur of the pyrites, is refractory to amalgamation. The bankets, of which generally only two beds are workable, are interstratified with quartzites. At the outcrop, by reason of the oxidation of its pyrites, the hard banket is altered into a soft, ferruginous mass, with the whole of its contained gold capable of amalgamation.

The author describes the necessarily primitive methods of transport and of mining which obtained when what is now Johannesburg was a mere medley of tents and corrugated iron huts known as Ferreira's Camp. As the workings got down to the hard, unweathered rock, mining was carried on at a loss, because the refractory gold (half of the whole) was sluiced away in the tailings. Ruin was, however, averted by the discovery of coal at Boksburg and elsewhere, by the building of railways, and by the introduction of the MacArthur-Forrest cyanide process—with the consequent putting-down of improved plant and machinery.

Very clearly and emphatically does the author set forth the grievances connected with the "monstrous dynamite-concession," the prohibitive freights charged on coal and other articles of necessity by the Transvaal State (Netherlands) railways, the amazing passenger tariff, the excessive import duties, the bribed connivance of the Pretoria Government in the illicit drink traffic, and the equally flagrant connivance of the precious Transvaal police in the thefts of gold by natives.

Despite the refusal of the Volksraad to sanction the reforms recommended by their own Commission of Inquiry, there were on December 31st, 1898, no less than 77 companies working gold-mines in the Transvaal, with a total output during that year of 8,979,428 tons of ore, producing 4,295,608 ozs. of gold, to the value of £15,141,376: this was equivalent to 28 per cent. of the total gold-production of the world during 1898. L. L. B.

SILVER-MINES IN THE PROVINCES OF COQUIMBO AND ATACAMA, CHILE.

Ueber einige Erzlagerstätten der Atacamawüste. By OTTO NORDENSKJÖLD. *Bulletin of the Geological Institution of the University of Upsala,* 1898, *vol. iv., pages* 28-44, *with* 4 *figures in the text.*

In this paper the author continues the study of the ore-deposits of the Atacama Desert commenced by him in 1897.*

East-north-east of La Serena, between latitudes 29 degrees and 30 degrees south, and within the area of Mesozoic rocks, but not very far from the boundary of the older coastal granite, lie the important mines of Arqueros, Rodaito, Condoriaco and Quitana

Arqueros.—This deposit was discovered in 1825, and proved to be one of the richest in all Chile. It is said that $20,000,000 worth of silver was got from the Mercedes mine alone, but at the time of the author's visit mining operations had almost completely ceased. In addition to its great mineral wealth, the deposit is remarkable for the peculiar mode of occurrence of the silver, which is nearly all in the form of a combination with mercury (Ag_6Hg), known as arquerite. The nearly vertical main leader strikes north-west and south-east, and is traversed by another striking east and west; the richest finds of ore were struck at the points of intersection of the two leaders. About 1¼ miles farther south is another leader (Cerro Blanco). The chief constituent of the gangue is a manganiferous calcspar, while heavy spar appears to be restricted to the lesser veins. The country-rock is a chocolate-brown brecciiform or tufaceous porphyrite cropping out at the surface, and it is noted that the veins are metalliferous only so long as they course through that rock.

* *Trans. Inst. M.E.*, vol. xvi., page 542.

About 200 feet down, another rock comes in, and though the veins go on through it they are quite barren. The Mercedes mine is the only one where the exploration has been carried to a considerable depth (910 feet), but practically no ore has been got below the chocolate-coloured porphyrite. The lowest rock reached is a compact grey limestone of Neocomian age, and here a little silver begins to come in again, but not in payable quantity.

Rodaito.—This mine is about 6¼ miles south-east of Arqueros. Here again the chief ore is a silver amalgam, but its constituents are not combined in the same proportions as in arquerite. Moreover, here, horn-silver occurs somewhat abundantly, and, in addition to the gangue-minerals noted at Arqueros, quartz and prehnite play an important part. Mining operations have been stopped here also: the shaft goes down to a depth of about 180 feet vertical, through a rock which in its reddish hue and general appearance recalls vividly the porphyritic tuff or *manto pintador* of Arqueros. It is, however, a massive melaphyre, the groundmass of which is chiefly made up of broad laths of plagioclase-felspar. Doubtless the Arqueros rock is in reality a tufaceous or brecciiform derivative of the Rodaito melaphyre.

Condoriaco.—These mines, about 50 miles from La Serena and 12¼ miles from Arqueros, were opened up only about 20 years ago, and are still in full activity. There are no less than 40 of them, the most important being the Mercedes and San José mines. Up to the end of 1893, the output from these two mines alone had been 14,400 metric tons of ore, producing about 1,210,500 ounces Troy of fine silver. The percentage of silver is especially high in the San José ore, which moreover contains gold in the proportion of about 1-10th of the silver: the gold-content is even higher in some of the smaller mines, such as the Marcellina.

The veins are very various in character, and in some the gangue is chiefly calcspar, in others quartz. In the upper levels are found *metales calidos*, that is, native silver and horn-silver; while in the lower levels, silver-glance, polybasite, argentiferous galena and silver-telluride are met with. The predominant rock, which is essentially the "country" of the richest veins, is a light-coloured, quartziferous, brecciiform porphyry. A greenish, perhaps more basic variety crops out at the surface, and is generally barren. The latter observation applies to a pinkish variety of the same rock found in the neighbourhood of the Sol mine, and to the *manto broceador* (microscopically indistinguishable from it) found at the lowest depths, say 1,100 feet, of the Mercedes mine. Small crystals of pyrite are abundant in all these rocks.

Quitana.—About 4¼ miles to the west are the argentiferous deposits of Quitana. The only important mine that works them is La Veterana, opened up about 15 years ago. It is probably the richest mine in all the province of Coquimbo, and has been proved down to a depth of 900 feet or so. The deposits are dissimilar in character to those hitherto described: the dominant rock is a highly decomposed, compact "greenstone" or augite-porphyrite. The main leader strikes east and west, and pitches steeply to the north; it is crossed by a system of minor fissure-veins running north-east or east-north-east, and is richest at the points of intersection with these, but not so at the points of intersection with other minor veins striking north and south. The whole complex is cut across by a great dyke of compact, light-coloured micro-granite. East of this dyke occur the richest masses of ore, while there is a notable "dying-off" of the ore west of it. At Condoriaco, the vein-mass consists largely of mylonized "country," but at Quitana the gangue is an angular breccia of "country" and quartziferous material. At the higher levels, the ores are native silver, horn-silver and iodide of silver; at the lower levels

the ores are silver-glance, polybasite, pyrite, chalcopyrite, arsenical pyrites, etc. The gangue-minerals are quartz, calcspar, and in places laumontite, but heavy spar does not occur.

Chimbero.—Leaving now the province of Coquimbo for that of Atacama, we come to the celebrated silver-mines of Chimbero, whereof the most considerable is the Buena Esperanza. The predominant rocks of this neighbourhood, 38 miles north-east of Copiapó, are Jurassic limestones and sandstones. These sedimentaries are not seen in the mine, however: here the chief rock is a quartz-porphyrite or dacite in an apparently bedded mass, while the metalliferous veins are intimately associated with a basic eruptive (andesitic) rock. But the richest ores do not occur so much in the main leader as at its points of intersection with the "bedding-planes" of the "country," and for some little distance along those planes, which dip on either side about 35 degrees towards the main leader. These planes are slickenside-faces or zones of crush, and in some cases regular friction-breccias have been formed along them. At the outcrop, the chief ore is horn-silver, but at the lower levels silver-glance, polybasite and pyrargyrite come in. The main leader ceases to be metalliferous at a depth of about 500 feet vertical; to the northward the ore-bearing rocks are completely cut off by the Jurassic sedimentaries; while to the southward several eruptive dykes come in, beyond which the main leader continues (though devoid of silver), and pyrite is met with in abundance.

The author explains the origin of these Chimbero ore-deposits as follows: —In late Mesozoic times, in connexion with the eruption of the augite-porphyrites, a great fissure was torn in the older porphyrites. On either side of this fissure there was a sagging of the rock-masses, with slipping along lines of weakness or planes of bedding, resulting in crush and brecciation. Thereafter, from solutions percolating upwards, were precipitated the metalliferous ores in the mass that was enclosed between the sedimentary rocks and the porphyrite-dykes, deposition taking place in the fissures and clefts as well as along the "bedding-planes" in their immediate vicinity. Thus originated the pseudo-stratified ore-deposits, dipping on either side towards the main leader, as seen in the Buena Esperanza mine.

Tres Puntas.—Barely 4 miles north of that mine is the silver-ore district of Tres Puntas, formerly very rich, but no longer worked nowadays. The metalliferous veins run in various directions, are often much faulted, and sometimes contorted: they generally become poorer in depth, although some of the mines have gone down very deep. It is proposed to start work again, as the very irregularity of the ore-occurrence induces prospectors to believe that careful search will reveal hitherto undiscovered deposits.

Chañarcillo.—The glory has departed, too, from the Chañarcillo silver-mines, at one time the most productive in all Chile, and perhaps the richest that have ever been discovered. Though the author admits that they have been fully described by previous observers, he thinks it advisable to describe them anew, adding some fresh details as to the microscopic characters of the rocks. One important feature which differentiates this district from the others dealt with in this paper, is that the ores are richest where associated with the sedimentary rocks, and all but vanish where the eruptives come in.

L. L. B.

MINERAL INDUSTRY OF ECUADOR, SOUTH AMERICA.

E tado de la Industria Minera en el Ecuador. By W. HIGGINS. *Boletin de la Sociedad Nacional de Mineria (Santiago de Chile),* 1899, *series* 3, *vol. xi., pages* 310-312.

At no time under the Spanish sovereignty did the mineral industry of Ecuador attain a development comparable with that of Peru, Bolivia, Colombia or Mexico. Since the declaration of independence, one of the principal checks to progress in mining has been the want of good roads. Moreover, much of the area where minerals could be found is covered by dense tropical forest.

The uninterrupted belt of porphyries which runs along the chain of the Andes is seamed with metalliferous veins, which mostly in the south of Ecuador are gold-bearing, while in the centre and north they are silver-bearing. All the streams which run down from the mountains to the Pacific seaboard, with a course from east to north, carry gold sands in their waters, while their banks are dotted with alluvial gold-deposits.

Mining was started in the Zaruma gold-field as long ago as 1549, and, after a long period of abandonment and various more or less unsuccessful fresh starts, the field is now being worked chiefly by an American company. Veins of auriferous quartz are crushed, containing about £3 6s. worth of gold per ton: of this only about a third can be extracted by amalgamation, the remainder being got out of the tailings by the cyanide-process. An Ecuadorian company is also at work in the field, restarting some old mines that date from the Spanish domination, and very rich samples of quartz have been got from this property. The average gold-content of the Zaruma ores is ¾ to 1 ounce per ton. Going from the surface downwards, to a variable depth, the gold occurs in the metallic state, and it is found that the deeper down the workings go, the more do the sulphides increase, and gradually also the proportion of gold. Thus in the Bonanza mine, there is as much as 20 ounces of gold per ton, with a large percentage of silver. The thickness of the veins, of which there are 200 or more proved, varies considerably, but the normal thickness is about 36 or 40 inches. This gold-field is not far from the coast, water-power is abundantly available, good timber is to be got in the neighbouring forests, and the most urgent need at present is a tramway for the transport of machinery, etc.

Another American company has re-explored the vast gold-placers of the province of Esmeraldas in the north of Ecuador: these were in part worked when the country was under Spanish rule. Canals are now being dug to carry water for hydraulicking the alluvial deposits. These are 80 feet thick, and the first washings carried out on a great scale have yielded 15 to 20 *centavos* of gold per cubic metre [of gravel]: say, about 9d. per cubic yard The placers and river-sands in the east of the country would prove highly remunerative and easy to work, but so far the necessary capital has not been forthcoming.

Abandoned silver-mines are to be found in the provinces of Cañar and Aznay. One mine, near Azogues, was re-explored and started afresh in recent years (1891-1894), being worked by means of three shafts and several levels. The lessees experted to Germany 70 tons of ore, containing no less than 9 parts of silver in 1,000. Water-power, timber, and firewood were all available within a short distance of the mine.

Argentiferous galena also has been proved in the province of Aznay. but

here again the want of capital has stopped further operations, and the mining industry of Ecuador is still in its swaddling-clothes.

The Mining Code, amended in 1892, and largely adapted from that of Chile, is very liberal. L. L. B.

THE GOLD-DEPOSITS OF NEVADA COUNTY, CALIFORNIA.

By G. P. Grimsley. *Engineering and Mining Journal* [*New York*], 1899, *vol. lxviii., page* 487, *with* 1 *illustration.*

Nevada County, the leading gold-mining county in California, is located about 100 miles east of San Francisco, in the Sierras. The county is 75 miles long, and from 25 to 75 miles wide. The deposits of auriferous gravel, often 200 feet deep, mark the ancient river-channels, but are, for the time being, out of reach, on account of the defects of the older methods. Some of this is now recovered in drift-mines, where from 2 to 5 feet of the gravel near the bed-rock is taken out and washed, paying from 8s. to £2 12s. (2 to 13 dollars) per ton. Quartz-mining properties, abandoned because they were thought to be exhausted, have been re-opened, and new levels driven, resulting in a number of cases in finding new and rich leads. In order to secure a permanent water-supply for the various mines, several companies have constructed in the mountains a series of artificial lakes, and leading from these 800 miles of canals, at a cost of many millions of dollars.

There are, at the present time, two centres in the district, viz:—Nevada City and Grass Valley, 6 miles apart. In the former, the rocks are diabase, granite and slate. The larger veins are near the contact of the granite and slate, and vary from 2 to 6 feet in width, though important mines are wholly in the granite, where the veins run from 6 inches to 3 feet. The ores are pyrite, chalcopyrite, galena with gold, the higher grades running as high as £60 (300 dollars) and the lower from £1 12s. to £8 (8 to 40 dollars) per ton. The leading mines are from 1,000 to 1,800 feet deep.

In the Grass Valley district, the veins average about 2 feet, and 4 inches veins have been worked with profit. The rocks are similar to those of the Nevada City district, with the addition of serpentine and diorite. The gold ore is associated with pyrite, chalcopyrite and zinc in quartz and a considerable amount of free gold is obtained.

A remarkable feature in the Grass Valley district is an enormous air-compressor, installed at the North Star mine on Massachusetts Hill. A 30 feet Pelton wheel, constructed of steel, with bronze cups, and making 65 revolutions per minute, is driven by a water-pressure of 335 pounds per square inch, controlled by a nozzle regulated by an automatic governor. A duplex air-compressor is attached directly to the axis of this wheel, with the low-pressure-cylinders 30 inches in diameter and the high-pressure cylinders 18 inches. The output of the compressor is 300 horsepower, and the air, at 90 pounds pressure, is conveyed 800 feet to a Corliss pneumatic hoisting-engine of 100 horsepower, and to a 75 horsepower compound pump. The air also works the drills in the mine. X. Y. Z.

NEWHOUSE TUNNEL, COLORADO.

Anon. *Engineering and Mining Journal* [*New York*], 1899, *vol. lxviii., page* 466.

This tunnel is 7,670 feet long, and is close to the veins of Seaton mountain. When completed it will be about 5 miles long, reaching the Eureka mine at

Central City, 1,500 feet below the surface. In the distance to be driven there are 1,140 known veins, of which 200 are mines. The greatest depth of the tunnel will be 2,400 feet below the surface. The average depth of cutting all lodes will be almost 2,000 feet. The tunnel measures 16 feet by 12 feet, and power will be furnished to anyone desiring to work a property through the tunnel, the object being to have 500 men at work on the various lodes within 12 months.
X. Y. Z.

GRAVEL-MINING IN IDAHO.

The Twin Springs Placer Company, Idaho. By H. L. J. Warren. *Engineering and Mining Journal* [*New York*], 1899, *vol. lxviii., pages* 395-396, *with* 4 *illustrations.*

The Twin Springs Placer Company own 3,500 acres of proven gold-bearing ground on Boise river in Elmore county. After recounting the careful operations by which the value of the ground has been conclusively proved, the author states that the principal workings, thus far, begin 1,500 feet up the river from Twin Springs. There is a flume, 9 miles long, conveying water from Brown Creek, Logging Gulch and Sheep Creek to the benches. The main flume is 6 feet 2 inches wide, 7 feet high, to carry 5 feet depth of water; the grade is 10·8 feet per mile, and its estimated capacity is 10,000 miner's inches. Along the line of the flume are several high trestles, one 127 feet above a deep gulch, also 2 tunnels. Sheep Creek, which furnishes the main water-supply, is on the south-eastern side of Boise river, whilst Twin Springs and the chief benches, where piping is now carried on, are on the opposite side. A distinctive feature is the inverted syphon which brings the Sheep Creek water across Boise river and discharges into the flume on the edge of the opposite bluff. The difference of elevation between intake and discharge of syphon is 35 feet, the total length of syphon is 1,780 feet and the bottom of syphon (supported on a bridge 110 feet above the stream) is 410 feet below the intake's horizon. The interior diameter of the intake is 6 feet, and the remainder of the pipe is 4 feet in diameter. The upper pipe-section on either side is $\frac{3}{8}$ inch steel; middle, $\frac{1}{2}$ inch; bottom section, $\frac{5}{8}$ inch; and elbows, $\frac{1}{8}$ inch thick. There are 4 expansion-joints, and air-valves are provided at each 50 feet in elevation. The pipe was hauled from Boise to Logging Gulch in 15 feet sections, there lowered by windlass on a truck, thence carried along the flume-grade to the syphon site, next lowered and hoisted into place, and finally rivetted. In the construction throughout there was no mishap of any sort, and from the first the syphon has never leaked nor occasioned a moment's trouble or uneasiness.

In character, the gold in large part is clean, bright, medium weight (distinctly so compared with Snake River gold), while the fine colours mostly have a much greater compactness than flour gold, so that a much larger proportion than usual (in Idaho) is recovered in the sluices. The gold is comparatively free from silver, the fineness varying from 0·840 to 0·912. Ordinarily, these gravel-beds are from 15 to 70 feet thick, with values quite generally well distributed from top to bottom. The gold-content varies from 7½d. to 2s. 11d. (15 to 70 cents) per cubic yard. In the benches thus far opened, there are not many large boulders, and piping is conducted with fewer obstacles than usual.
X. Y. Z.

VERIFYING THE VERTICALITY OF BORE-HOLES.

Note sur une Méthode employée pour Vérifier la Verticalité des Sondages. By — BARILLON. *Comptes-Rendus mensuels des Réunions de la Société de l'Industrie Minérale,* 1899, *pages* 108-111.

The method consists in suspending at a sufficiently great height, exactly over the centre of the bore-hole at the level of the soil, a plumb-line carrying at its lower end a loaded cylinder nearly as large as the hole. For a hole 8·7 inches (22 centimetres) in diameter, the cylinder has a diameter of 8·3 inches (21 centimetres) and is formed of wooden laths nailed to two slight discs, being loaded with 15 pounds (7 kilogrammes) of lead-shearings, so that it can be easily destroyed by the boring-tool if it should fall to the bottom. On being let down into the hole, the cylinder slides along the inside, following its deviations. If the deviation, d, from the centre at the level of the surface, the height, h, of the point of suspension, and the depth, n, of the cylinder in the hole be measured, the deviation, D, at that level will be given with sufficiently near approximation by the formula $D = d \times (h + n) \div h$. The value of the method was tested by tracing on a plan, at the surface-level and also at a depth of 295 feet (90 metres), 20 bore-holes distributed over a circumference of 23 feet (7 metres) diameter for freezing the ground, so as to permit of sinking a shaft 16½ feet (5 metres) in diameter and put down to the depth of 295 feet (90 metres). With two exceptions, the holes were found to have been bored truly, not one of them having entered the portion to be excavated, while the greatest deviation observed was 26 inches (0·656 metre).

J. W. P.

METHOD OF WORKING THIN SEAMS.

Note sur une Nouvelle Méthode d'Exploitation appliquée aux Gîtes Minces. By — HAVARD-DUCLOS. *Comptes-Rendus mensuels des Réunions de la Société de l'Industrie Minérale,* 1899, *pages* 118-127, *and* 3 *plates.*

No. 18 coal-seam, 31 inches (80 centimetres) thick, worked at the Lens colliery, is tolerably regular, having only 25 per cent of disturbances; and the average dip is 15 degrees. Down to the end of 1896, this seam was generally worked by rising stalls, a main rolleyway being driven, from which the stalls were turned off every 52 feet (16 metres) and, in the regular portions, carried to a distance along the rise of about 240 feet (75 to 80 metres). At this height, a fresh level was driven, from which a second series of rising stalls were turned away, and so on until the stage was completely worked out; but in the irregular portions the coal was taken out as best it might be. As regards the actual getting of coal it would at first sight appear that this method has many advantages; but this was not found to be the case as regards packing and laying the rails, so that it was eventually superseded by a new method of long forward stalls with complete packing.

This latter method consists in taking up from the rolleyway an incline which is carried to the height of 400 feet (120 metres); and at its head a compressed-air winch draws up the packing material. On each side of the incline, forward stalls are driven, one above another, and served by passes. The roads, about 130 feet (40 metres) apart, are driven for about 330 feet (100 metres) from the incline, at which distance an incline is again passed, whereon are again established the three 130 feet (40 metres) stalls, and so on; and, when the boundary of the district is reached, the

first incline is continued by pushing it forward 400 feet (120 metres) thus starting a second intermediate stage. The packing material is drawn up the incline by the winch, the tubs being led to the top of the stalls and tipped there, and it is afterwards packed in the stall by the afternoon shift by means of plate-iron shoots.

This method has now been in operation for two years with a considerable reduction in the cost of getting, the men being exclusively engaged in miner's work, *i.e.*, getting and timbering. Besides the lower cost of getting—almost 50 per cent. as compared with the method by rising stalls—the expenses under other heads have been reduced, especially the leading of packing material, the services of a night-loader have been dispensed with; and in addition the suppression of the incline-heads in the roof and the complete packing of the stalls afford conditions very favourable to safety, while the tight packing of the stalls is excellent as regards ventilation and the removal of fire-damp. J. W. P.

EXPERIMENTAL EXPLOSIVES GALLERY AT THE MARIA COLLIERY, NEAR HONGEN, IN THE DISTRICT OF AACHEN.

Die Versuchsstrecke auf der Steinkohlengrube Maria, bei Höngen, im Bergreviere Aachen. By BERGASSESSOR SARTER. *Glückauf,* 1899, *vol. xxxv., pages* 561-564, *with 2 illustrations in the text and 1 plate.*

The proposed order by the Bonn mining authorities as to rendering coal-dust non-dangerous has induced the colliery-owners of the Wurm and Indemulde districts to erect an explosives testing-station; and its erection, maintenance and management have been entrusted to the authorities of the Bardenberg School of Mines.

The Maria colliery was selected for the erection of this experimental gallery, chiefly on account of the fact that natural pit-gas was there available. The experimental gallery is constructed along the southern edge of the waste-heap, and is built into a block of masonry. Close to this lies a building containing the fan and ball-mill; and 60 feet distant, and facing it, lies the house from which observations are made, this being so placed that the central line of the building intersects the axis of the experimental gallery at a distance of 50 feet from the block of masonry. Westward from this house there are two boilers, which act as reservoirs of pit-gas. A short distance away is the explosives magazine.

The gallery is elliptical in cross-section, 6·1 feet (1·85 metres) high and 4·6 feet (1·4 metres) wide, and consists of frames made of strong double T-iron which are spaced 17·7 inches (450 millimetres) apart for the first 32·8 feet (10 metres), and 22 inches (560 millimetres) apart throughout the rest of the length of the gallery. The frames are lined internallly with three thicknesses (breaking joint) of pitch-pine 1·2 inches (30 millimetres) thick, grooved and tongued. The planks and supports are coated with tar mixed with a certain amount of cement. The gallery abuts against a block of masonry, which is bound together with rails, and is 13 feet (4 metres) in height and 11·9 feet (3·6 metres) square in plan. The masonry extends beyond the bottom end of the gallery for a thickness of 3·3 feet (1 metre) externally and 2·9 feet (90 centimetres) internally. The projecting length of the gallery amounts to 131 feet (40 metres). The gallery slopes towards the mouth with a dip of 1 in 100, and is connected with a ditch which passes in front of it. There are 22 sight-holes in the length of the gallery, situated three-quarter way up its side. They are spaced closer together near the closed end and farther apart

towards the open end. Each sight-hole consists of two cast-iron frames, bolted together, between which plates of glass 1 inch (25 millimetres) thick are secured and rendered air-tight by means of rings of asbestos and india-rubber. The available opening of these windows is 9·8 by 4·7 inches (250 by 120 millimetres). In the roof of the gallery, there are 4 safety openings, 9·8 inches (250 millimetres) in diameter, which are closed by means of wooden plugs attached to chains; and these are distributed through the first 33 feet (10 metres) of length of the gallery.

The gas-intake enters the lower part of the gallery 8·2 feet (2·5 metres) from the cannon. In the roof there is a charging-hole for the coal-dust to be tested. The latter falls upon the vanes of a fan, which can be rotated at a rapid speed by means of gearing in the proportion of 1 to 6, and which also serves for the uniform diffusion of gaseous mixtures.

In order to be able to form two explosion-chambers of 353 or 706 cubic feet (10 or 20 cubic metres) capacity, there are two fixed iron frames furnished with loose iron rings situated at distances respectively of 16·2 and 32·4 feet (4·93 and 9·86 metres) from the closed end. These can be covered with paper when experiments are being carried on, and thus form the explosion-chambers. Heating-pipes have been built in so as to enable the chambers to be warmed in case of need by means of steam.

In the block of masonry, there is only space for one cannon, situated close to the bottom of the gallery. Experiments having proved that shots starting from the bottom and pointing upwards produce the longest flame, the cannon is inclined upwards at an angle such that the prolongation of its axis cuts the roof of the gallery 32·8 feet (10 metres) from its end. The shots are fired electrically from the house destined for the observers. After a shot has been fired, the gallery can be freed from gas by means of a conical iron tube built into the block of masonry, the tube being so connected with the fan that communication can be closed or opened as required.

The building containing the engine is divided into two spaces: in the front one is a Pelzer fan, 19·7 inches (500 millimetres) in diameter and having a maximum capacity of 2,100 cubic feet (60 cubic metres) per minute. It is driven by means of belting from a 10 horsepower engine. This engine also drives a Krupp ball-mill, capable of grinding 33 pounds (15 kilogrammes) of dust per hour through a sieve of 8,064 meshes per square inch (1,250 meshes to the square centimetre).

The ball-mill was erected, as it was not always possible to obtain natural coal-dust in sufficient quantity and in suitable form; and it was also thought well to institute systematic tests on the coal of all the seams, while a provision of artificial coal-dust was indispensable in the tests on explosives, etc., that it was intended to carry out.

The building for the observers has, on the side nearest the gallery, a slit at the height of the observer's eye. This slit, 7·8 inches (20 centimetres) wide, is closed by a sheet of glass, 0·8 inch (20 millimetres) in thickness. This building, next to which there is a small office, contains a gas-meter with a capacity of 530 cubic feet (15 cubic metres) per hour, used to measure the gases introduced into the explosion-chamber; an electrical shot-firing machine; scales, barometer, thermometer and hygrometer.

The pit-gas is forced into the reservoirs by means of a steam-jet; and the whole length of the experimental gallery is furnished with water-pipes and with tubes leading to the air-compressor of the mine. By this means compressed air can be conveyed into the gallery, and can be employed when it is required to produce flames of exceptional length.

H. L. and J. W. P.

THEORY OF SAFETY-EXPLOSIVES.*

Zur Theorie der Sicherheits-Sprengstoffe: Eine Erwiderung auf mehrere Kritische Besprechungen. By BERGASSESSOR HEISE. *Glückauf*, 1899, *vol. xxxv., pages* 733-738.

This article consists of a reply by the author to criticisms upon his previous papers.† The labours of the French Commission have proved that safety-explosives must fulfil the two following conditions:—(1) That its temperature of detonation shall remain within definite limits, which must not pass 2,200° Cent.; (2) that it shall detonate and not deflagrate. According to French law, the use of black powder is absolutely forbidden in mines, and it is enacted that an explosive to be used in coal must have a temperature of detonation of less than 1,500° Cent., and in stone of less than 1,900° Cent. Since then, it had, however, been found that safety-explosives that fulfil the French conditions show remarkable differences in their safety when used in fire-damp. The author attempted to show that these differences could not be explained by the temperature of explosion within the limit of 2,200° Cent., but that the velocity of explosion had an important influence upon the question of safety. In making this statement he still adhered, however, to the French theory in this sense, that the conclusion which he had stated was only true for safety-explosives, namely, such explosives as fulfilled the above conditions; and it was, therefore, not correct to state that he had attempted to replace the French theory by one of his own.

H. L.

DETONATION OF FAVIER GRISOUNITES.

Commission du Grisou: Rapport sur des Expériences relatives à la Détonation des Grisounites Favier. By E. SARRAU. *Annales des Mines*, 1899, *series* 9, *vol. xv., pages* 232-243.

In consequence of a further accident occurring through the miss-fire of grisounite-cartridges, the French Fire-damp Commission decided to carry out some experiments as to the manner in which the grisounites decompose, with the object of determining whether it were possible to realize experimentally the manner of exploding which appeared capable of accounting for the miss-fires to which the accidents were attributed. This explanation consists in supposing that (1) owing to defects of priming, or of the priming substance, a grisounite-charge may ignite and fuse slowly into the shot-hole, and (2) owing to circumstances inducing an increase of pressure this fusing decomposition may suddenly be changed to detonating decomposition.

The experiments were carried out by the engineers of the Esquerdes powder-mill on (*a*) *grisounite-couche* (for coal), composed of 4·5 per cent of trinitronaphthaline and 95·5 per cent. of ammonium nitrate; and (*b*) *grisounite-roche* (for stone) composed of 8·5 per cent. of dinitronaphthaline with 91·5 per cent. of ammonium nitrate, the former explosive being merely pressed slightly into cases of thin cardboard, and about four-fifths of the latter being compressed into a hollow cylinder containing the rest of the charge in a pulverized state, for receiving the action of the detonator and transmitting it intensified to the compressed portion of the charge.

* *Trans. Inst. M.E.*, vol. xvi., page 555.

† (1) "Zur Theorie der Sicherheits-Sprengstoffe," by Dr. Julius Ephraim. *Zeitschrift für Angewandte Chemie*, 1898, No. 47. (2) "Les Explosifs de Sûreté," by Victor Watteyne and Lucien Denoel. *Annales des Mines de Belgique*, 1898, vol. iii., page 801. (3) "Note sur les Recherches récentes concernant les Explosifs de Sûreté," by G. Chesneau. *Annales des Mines*, 1899, series 9, vol. xv., page 263.

Endeavouring to imitate the conditions that govern the explosion of charges in a shot-hole, the engineers placed in a brass tube a cartridge of *grisounite-roche*, of which one-fourth the pulverulent charge, or 0·1 ounce, had been replaced by the same weight of very fine gunpowder; they inserted in the latter the end of a safety-fuse, and surrounded the whole with sand that filled up the tube, which latter was closed at each end. On the charge being fired by the fuse, no report was heard; and, after 2 minutes had been allowed to elapse, the tube was dismounted, when the cartridge was found unaltered, the priming of gunpowder having been entirely consumed, while the surface of the Favier explosive in contact with it was scarcely blackened.

The engineers then endeavoured to ascertain whether the fusing decomposition could not be obtained by the use of detonators under conditions producing a miss-fire; and for this purpose they employed 4 detonators of increasing power. On the above-named experiment being repeated, but with one of the most powerful detonators placed at the end of the fuse, it was found that the portion of cartridge where the detonator had exploded was broken, but that there was no trace of detonation of the rest of the charge, not even of the pulverulent substance.

In order to decide the question whether, under the supposition that the pulverulent substance might explode without the explosion being propagated to the compressed matter, the latter could ignite so as to give the fusing decomposition, a special cartridge, in which the density of the compressed portion had been increased from 1·15 to 1·60, was placed at the bottom of the lower one of two cylindrical leaden blocks with concentric holes, 1·38 inches (35 millimetres) in diameter, on a plate of chrome-steel, 1·18 inches (3 centimetres) in thickness. On the pulverulent substance being fired by a detonator, it was always found that the fragments of the compressed portion remained absolutely unchanged.

It follows from the results of the numerous experiments made under the most varied conditions, without anything in the nature of delayed explosions having occurred, and without there having been any confirmation of the hypothesis put forward to account for them, that it must be concluded, with a probability verging on certainty, that the explosive action of the grisounites is attended by no circumstance that need prevent or restrict their use; but the workmen employing them should, when they notice any sign of an incomplete explosion, allow a few minutes to elapse before returning to the shot-hole, and in the meanwhile should remain in a place of safety.

J. W. P.

AN INCANDESCENT IGNITER.

Fortschritte auf dem Gebiete der elektrischen Zündung von Sprengschüssen. By Bergassessor Heise. *Glückauf*, 1899, *vol. xxxv.*, *pages* 437-443, *and figures.*

During the last two years, igniters, called *spaltglühzünder*, taking a middle position between spark and incandescent igniters, have been used in the Dortmund district for firing single shots. They are essentially incandescent igniters; but the platinum-wire is replaced by finely-divided conducting substance, such as graphite or coal-dust, mixed with the igniting substance, and the resistance opposed to the current is far greater than that of a small platinum-wire, being generally about 5,000 ohms. The quantity of current required to ignite the few particles of dust between the ends of the poles is very slight, not exceeding a few thousandth parts, or at most one

hundredth of an ampère; and such igniters combine the advantages of both spark and incandescent ignition without their disadvantages. Owing to the conducting capacity of the igniting substance, each detonator can be tested before being used, so that, with proper manufacture and treatment, miss-fires should not occur; and yet the resistance of the igniter is so great that, when iron wire is employed, the resistance of the conductor is a matter of no consequence, so that this cheap material may be used, and the insulation of the conductor need not be very perfect. These igniters have lately been made with a resistance of less than 100 ohms, so that they have been used in wet workings with uncovered iron wires for conductors. Some tests have been carried out at the testing-station of the Westphalian Miners' Provident Fund, to ascertain the degree of reliance that can be placed on these igniters; and for the sake of simplicity in testing, the igniters were tested before they received their detonating cap, a double iron-wire cord, 330 feet (100 metres) long, being used for the conductor; and not a single miss-fire occurred with the 1,500 igniters tested. In some trials of low-tension igniters for separate shots, a conductor consisting of two naked iron wires, 0·04 inch (1 millimetre) in diameter, and 164 feet (50 metres) long, was used, and the conductors were immersed in water for a length of 10 feet (3 metres), while there was a distance of only 4 inches (10 centimetres) between the two; and yet, notwithstanding these very unfavourable conditions, not one of the 1,500 igniters missed fire. To ascertain whether the efficiency of these igniters would diminish in the course of time, 500 were stored for 8 weeks, and then fired without a single miss-shot.

When using the new igniters for series-firing, to make sure that they will not miss-fire, two conditions are necessary:—(1) Each igniter must have, as far as possible, the same resistance; and (2) a firing-machine must be used in which the quantity of current is not dependent upon the speed with which the handle is turned or upon the skill of the operator. In the first experiments at the above-named testing station, the second condition was not satisfied, as the shots did not ignite together, although each individual igniter was afterwards exploded by a strong current; but satisfactory results are now obtained with a firing machine, the efficiency of which does not depend upon the operator.

J. W. P.

CONSUMPTION OF EXPLOSIVES IN THE DORTMUND DISTRICT, GERMANY.

Ueber den Sprengstoffverbrauch auf den Steinkohlengruben des Oberbergamtsbezirks Dortmund im Jahre 1898. *By* Bergassessor Heise. *Glückauf*, 1899, *vol. xxxv., pages* 697-698.

The explosives used may be divided into three main groups, the first of which is black powder of three different compositions, the difference chiefly consisting in the saltpeter content, which is 65, 70 or 75 per cent.; the second group consists of dynamite, almost exclusively used in the form of gelatine-dynamite; and the third comprises nitrate-of-ammonium explosives and carbonit, including ammonium-carbonit C, dahmenit A (Victoria powder), Köln-Rottweiler safety blasting-powder, roburite I, westfalit, carbonit (Wittenberger wetterdynamit) and kohlencarbonit I. and II.

The total quantity of explosives used during 1898 was 4,033·257 tons, in the proportion, for the three groups above-named, of 332·292 tons, 2,247·799 tons and 1,453·166 tons respectively, for a total coal-production of 51,001,551

tons, showing a proportion of 176 pounds (79·1 kilogrammes) per 1,000 tons of coal drawn. In that year, 14 pounds (6·5 kilogrammes) of black powder was used against 17 pounds (7·8 kilogrammes) in 1897; and the dynamite-consumption had diminished, while that of safety-explosives had increased.

J. W. P.

UNDERGROUND EXPLOSIVES MAGAZINES.

Commission des Substances Explosives: Rapport sur les Expériences faites aux Mines de Blanzy le 6 *Juillet* 1898. *Étude des Conditions d'Établissement des Dynamitières Souterraines. By* H. LE CHATELIER. *Annales des Mines,* 1899, *series* 9, *vol. xv., pages* 523-532.

This series of experiments was made in order to determine the conditions under which small dynamite-magazines may be allowed underground, in which the daily consumption of explosives in the mine may be stored. The quantity of dynamite that is stored at one time varies, in general, between 1 and 5 boxes (44 to 220 pounds or 20 to 100 kilogrammes).

Two questions had to be determined: (1) what was the amount of destruction that the explosion of isolated cases of dynamite would cause to the essential elements of the ventilation, viz., doors and fans; and (2) was it possible by suitably arranging the cases to prevent the communication of the explosion from a case to its neighbours.

The first experiment was made with the object of determining the damage caused by the explosion of a case of dynamite to the doors and fans placed at different distances from the explosive. An old disused drift was employed for this experiment; a stopping was put into the drift 492 feet (150 metres) from its mouth. It was formed by a brick wall which was close stowed at the back for a length of 32·8 feet (10 metres). At the base of this wall, the case containing 44 pounds (20 kilogrammes) of No. 1 dynamite was placed; in front of it, a first door was erected 32·8 feet (10 metres) from the dynamite; a second door, 164 feet (50 metres) from it; and finally a wooden framework representing a fan was erected at a distance of 459 feet (140 metres). The gallery was 43 square feet (4 square metres) in cross-section. It was timbered, but the timber was in pretty bad order, and for a certain distance from the dynamite was repaired by means of middle props supporting the caps. The doors were built in brick walls 1 foot (0·3 metre) thick, the section of the doorway being half of the total section of the drift. The door itself was made of planks 4 inches (10 millimetres) thick, fastened to a wooden frame and fixed to two long iron straps carrying the hinges. The first door opened inwards, and the second door outwards. A light six-armed wooden frame was built to represent the skeleton of a fan; it occupied about two-thirds of the section of the gallery, and could be worked from the outside by means of a rope passing over a pulley.

The explosion of the dynamite produced an air-blast at the open end of the drift, and carried a cloud of smoke outward for a distance of about 16 feet (5 metres), followed by two smaller blasts, with intervals of about 1 second, and successively weaker. On entering the drift, it was found that one of the light wooden planks which formed the wings of the fan had been loosened, but nothing had been broken. A real fan, therefore, which would have been much stronger, would have suffered no damage. The second door, 164 feet (50 metres) distant, had been blown away bodily, and flung

a distance of 69 feet (21 metres), the ironwork having been torn off and twisted. The frame of the door was shaken, but the brickwork was intact. Beyond this, the roof of the drift had broken down; a strip of rock had fallen from the roof along the course of the drift for a length of 49 feet (15 metres) from the stopping, which barred the gallery. In all other places the woodwork was uninjured, but some of the middle props were thrown down. Four lamps, which had been placed on the floor of the drift at 66 feet (20 metres) from each other, beyond the second door, were all overthrown, and, therefore, extinguished. A lamp, which had been hung up beside the last one, was not extinguished. Upon the whole, it may be said that the conditions of the experiment were, as should always be the case, more severe than in actual practice. As regards fans, the experiment proved conclusively that at a distance of 492 feet (150 metres) they would not have been damaged by the explosion of one isolated case of dynamite. This condition might always be realized, having regard to the depth at which coal-mines are now working, and this question may therefore be disregarded. As regards the doors, the results obtained deserved closer discussion. The doors closing the magazines were completely swept away up to a distance of 164 feet (50 metres). The same result would probably have been the case at a distance of 492 feet (150 metres) or perhaps even of 656 feet (200 metres). There is therefore no hope that the underground magazines could be so built that in case of explosion the doors closing them should remain undamaged. In no case, however, should the magazines open into two different roadways, free communication between which might short-circuit the ventilating current in a section of the mine. If there are two entrances to the magazine, it must be placed parallel to one roadway and away from it, so that if completely destroyed the general scheme of ventilation will not be affected.

In addition to the doors of the magazine, attention must be directed to the much more important question of the doors that may exist in the neighbouring roadways where they are used for directing the air-current into the workings. These doors will be much less exposed, because they will only be reached by the explosive wave after this had been split up into several directions on leaving the magazine. On condition that the dynamite shall be stored at a distance of at least 656 feet (200 metres) from doors used for ventilation, no serious risk will be run. As an additional precaution, this distance may perhaps be doubled in certain exceptional circumstances, as, for instance, in the case of a pair of pits where the entire ventilation of the mine depends upon the doors that separate these pits from each other; and if so great a distance cannot be obtained, very strong iron doors should be used.

The second series of experiments was made with the object of finding a means of preventing the accidental detonation of a case of dynamite in an underground magazine from being transmitted to the neighbouring cases. The experiment was performed by enclosing each case of dynamite in a brick recess closed by an iron door, and separated from its neighbours by greater or lesser distances. By this means it was hoped that the case could be protected against the shock of explosion and the penetration of the heated gases. A drift was selected 95 feet (29 metres) long and 43 square feet (4 square metres) in area. It was walled with brickwork 14 inches (0·36 metre) thick for a length of 36 feet (11 metres) from the closed end, the remaining 52 feet (16 metres) being timbered. The brickwork was built with lime-mortar, had only been finished a fortnight, and

was therefore no stronger than dry-stone walling would have been. In this brickwork three recesses were left for the boxes of dynamite. They were placed at a mean height of 20 inches (0·5 metre) above the floor of the drift. Their brick walls were 12 inches (0·3 metre) thick. They were closed by doors of sheet-iron 0·4 inch (10 millimetres) thick, hanging by hinges at their upper edge and closed by a bolt at the bottom. The first recess was 3 feet (0·9 metre) from the end of the drift, the second was 10 feet (3 metres) from the first, and the third 20 feet (6 metres) from the second. The middle case of dynamite was fired, the door of the central recess being left open. The doors of the two side recesses were dropped, but the bolts were not shot home, as might in practice occur as the result of negligence. The detonation was not transmitted to either of the neighbouring cases, and their doors appeared not to have suffered in the least from the effect of the explosion. The case 10 feet (3 metres) away was only a little shifted in its recess, but without showing any indication of the planks being broken. The bad condition of the ground and the imperfect setting of the mortar had allowed sufficient lateral pressure to be transmitted to push in a little the brick chamber and at the same time to crack the cast-iron frame, which was carrying the door. The timbered portion of the gallery which was beyond the mouth of the brick portion was uninjured, and there were no falls, as might have been expected from the previous experiments; in this case, however, the timbering was new, whilst in the previous one it was old and in bad order.

The conclusion which might be drawn very definitely from these experiments was that even in exceptionally bad ground there was no danger of the transmission of explosion between cases of dynamite placed in separate recesses 10 feet (3 metres) apart. These experiments allow of a certain number of rules being formulated, the application of which would appear to prevent the possibility of any serious danger to a mine in the case of an explosion in an underground dynamite-magazine.

Each case should be enclosed in a brick recess closed by an iron door at least 0·4 inch (10 millimetres) thick, hung by hinges above so as to be self-closing, and so arranged that the weight of the door must close it thoroughly. It must be kept shut by means of a bolt at the lower edge.

These recesses must be 13 feet (4 metres) apart in soft ground, like coal and schist, and 10 feet (3 metres in hard ground, such as grit. The recesses shall be placed along the same side of the magazine, and never along its two opposite walls.

The magazine must be prolonged at each end into closed ends, at least 10 feet (5 metres) long, as shown by Fig. 1.

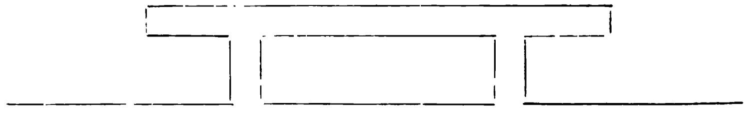


FIG. 1.

The closed ends may be utilized as chambers for opening the cases of dynamite and distributing explosives.

Each magazine shall communicate only with one roadway in the mine, and the communication from magazines to take more than 5 boxes shall

be by means of two separate roadways closed only by light lattice-doors, so as to secure sufficient ventilation.

Every magazine shall be at least 656 feet (200 metres) distant from any ventilating-door and, as far as possible 1,312 feet (400 metres) from any main ventilating-door, the destruction of which might cut off the ventilating-current from either the whole mine or an important section thereof.

H. L.

SINKING SHAFTS THROUGH QUICKSAND.

Note sur les Enfoncements des Puits No. 5, No. 6 et No. 7 du Charbonnage de Bascoup. By Edmond Briart. *Publications de la Société des Ingénieurs sortis de l'École Provinciale d'Industrie et des Mines du Hainaut*, 1898-99, *vol. viii., pages* 32-50, *with* 1 *plate.*

Whatever be the depth at which water-bearing sands may occur, precautions should never be neglected; and in sinking shafts through such measures the leading principle that should guide an engineer is the necessity of succeeding at any cost, although there is a limit of cost beyond which the work should not be undertaken. It is not always, however, the method that appears at first sight to be the most economical that is so in reality; and, although it is important to acquire a previous knowledge of the measures to be passed through, too much reliance must not be placed in the information afforded by bore-holes, especially as regards the shifting nature of the strata.

The No. 6 plant of the Bascoup colliery was to consist of two shafts of 14 feet (4·25 metres) in diameter; and their tubbing was to be carried up to within a few feet of the surface. Instead of using the definite tubbing for keeping back the water, the late Mr. Alphonse Briart decided to employ for this purpose an additional tubbing, of larger diameter, that should serve as a coffer-dam; and this outside tubbing need not be of great strength, or very carefully fitted, because it would not have to stand any great pressure of water, and would be removed on the completion of the sinking. It consisted of cast-iron rings 1 inch (25 millimetres) thick, 3¼ feet (1 metre) high, and 18 feet (5·5 metres) in outside diameter, divided into 10 segments, cast with 4 inches (10 centimetres) flanges, drilled with holes 9 inches (23 centimetres) apart. The first beds of sand were passed through by means of sheet-piling; but, on the quantity of water attaining 660,000 gallons (3,000 cubic metres) per 24 hours, a cutting crib was lowered carrying the ten lower rings. Pressure was given by 4 screws passing through strong oaken beams under a bed of pebbles, and exerting their effect on other beams fitted with wrought-iron plates laid on the top of the tubbing; and the passage of the cutting-shoe was facilitated by grabs, trepans, etc.

When the temporary tubbing was finished to within 33 feet (10 metres) from the surface, the water was still raised by three pulsometer-pumps, placed in the free space intervening between the tubbing and the inside of the shaft; and both shafts were cleared of sand down to the limestone, after which the sinking was continued by the ordinary method of pumping the water. Inside the temporary tubbing, a ledge was left 2 feet (60 centimetres) wide by 8·20 feet (2·5 metres) high, for forming the joint; and under this ledge the sinking was continued, while the diameter was increased progressively until the required dimension was attained.

The sinking was continued to a depth of 8·2 feet (2·5 metres) into the top of the Coal-measures in No. 1 shaft, and 15·7 feet (4·8 metres) in No. 2 shaft,

at which points the wedging-cribs were laid for carrying the tubbing, which consisted of rings 14·6 feet (4·45 metres) in diameter, having 4 inches (10 centimetres) flanges, and a thickness of metal decreasing from 1·18 inches (30 millimetres) for the 15 lower rings to 1·08 inches (27½ millimetres) for the succeeding 15 rings, and to 0·79 inch (20 millimetres) for the upper 10 rings. The part left for the ledge was then widened out to the full diameter; and the definite tubbing soon entered the temporary tubbing, the upper rings of which were then taken out, only 2 rings, in addition to the cutting-crib, being left in No. 1 shaft, and 1 ring only in No. 2 shaft, the space between the definite tubbing and the rock being run in with cement-concrete.

The single shaft of the No. 7 plant was sunk in the same manner as the shafts of No. 6 plant; but no bore-holes were put down, because it was known that there were at least two water-bearing strata to pass through. The upper water-bearing stratum was passed through without any great difficulty, by means of sheet-piling; and on the cutting-crib entering the clay at the depth of 87 feet (26·4 metres) the temporary tubbing was inserted up to 37 feet (11·4 metres) from the surface, the water being raised by a single pulsometer-pump. Sinking was then resumed, a 19·7 inches (50 centimetres) ledge being left as before; and the green-sand was reached at the depth of 118 feet (36 metres), when a feeder of at least 110,000 gallons (500 cubic metres) per hour was encountered. The difficulty became very serious on the lower bed of very fine and shifting sand being entered at the depth of 133 feet (40·5 metres). When, at the depth of 139 feet (42·4 metres), the first sheeting-pile was driven of what was thought to be the last series, a large quantity of sand burst in, and the work was stopped, because it was noticed that the shaft had shifted laterally while the lower tubbing-rings were canted.

Rather than run the risk of compromising the shaft, the engineers decided to employ a false or supplementary tube, provided with a cutting-shoe, and consisting of 2 steel-plate rings 1 inch (25 millimetres) thick, 15·2 feet (4·65 metres) in diameter, and about 5·1 feet (1·57 metres) high, divided into 5 segments, fitted with 3·9 inches (10 centimetres) angle-irons, forming flanges to receive the bolts, while the lower ring was cut out to the shape of the Coal-measure bed, as ascertained by boring. This false tubbing was sunk in the ordinary manner for 16·6 inches (42 centimetres) into the top of the Coal-measures. The operation caused great difficulty, owing to the sheeting-piles that had been used previously and had to be drawn out by grabs, pincers, etc. Sinking was then resumed, a ledge being left as before, until at the depth of 147 feet (45 metres) the wedging-crib was laid, 9·1 feet (2·8 metres) in the Coal-measures. The definite tubbing was then connected as quickly as possible, because the false tube had become oval in section owing to pressure, and there was only 0·1 inch (2½ millimetres) between the tube and the tubbing on the north side. When the definite tubbing was completed, the false tube was withdrawn, except the cutting-crib and the first ring; and cement-concrete was run between the tubbing and the rock. J. W. P.

EXTENDING AN AIR-SHAFT.

Charbonnage du Bois d'Avroy, Siège du Perron: Rectification du Puits d'Aérage. By V. FIRKET. *Annales des Mines de Belgique,* 1899, *vol. iv., pages* 361-363, *with sections.*

Between the surface and the level of 853 feet (260 metres), the air-shaft of the Perron pit is vertical and masonry-lined to a diameter of 9·8 feet (3 metres); but from that level to 1,411 feet (430 metres) it followed the inclination of a thin coal-seam, dipping about 80 degrees. When it was decided to carry the vertical portion deeper, the presence of the inclined portion through which the return air of the lower levels must continue to pass, rendered very difficult the sinking of the first length or section, between 853 feet (260 metres) and 1,007 feet (307 metres). The inclined shaft had a rectangular section of 6·5 feet (2 metres) by 11·4 feet (3·5 metres), and only diverged from the line of the new air-shaft about 36 feet (11 metres) below the level of 853 feet (260 metres); and as the masonry of this new shaft could take a bearing on the roof of the thin coal-seam, at the depth of 900 feet (274·5 metres), the sinking was effected in two sections, namely, from 853 feet (260 metres) to 900 feet (274·5 metres), and from that level to 1,007 feet (307 metres)

The excavation of the first of these sections was effected in an upward direction, and in short lengths—masonry-lined as soon as driven. Some timbers of the inclined shaft, which interfered with the work, were replaced by others; but the overhanging lining of the old shaft could be left in place. The long members of this lining rested on vertical timbers, distributing the pressure on the solid rock above and below the excavation; and the brattice-timbers were replaced by others arranged obliquely. The thickness of masonry is 3·3 feet (1 metre) on the side next the old shaft, and half that thickness on the other. The execution of the first section took up 4 months and cost £2 19s. per foot (245 francs per metre) for labour, because it was necessary to take great precautions in arranging the timbering, while the masonry had to set before the timbering could be allowed to bear against it.

J. W. P.

REPAIRING OF TUBBING IN A SHAFT.

Reparatur der Cuvelage des Schachtes I der Zeche Gneisenau bei Derne im Jahre 1898. *By* F. SCHULTE. *Glückauf,* 1899, *vol. xxxv., pages* 525-527, *with* 1 *plate.*

No. 1 shaft of the Gneisenau colliery, Westphalia, is tubbed from the depth of 484 feet (147·5 metres) to that of 800 feet (243·5 metres) with 61 cast-iron rings, 12 feet (3·65 metres) in diameter and 4·9 feet (1·5 metres) high, the thickness varying from 1·18 inches (30 millimetres) to 2·76 inches (70 millimetres). About 1890, it became evident, at the depth of 656 feet (200 metres), owing to the great pressure, that Nos. 35 and 36 rings were being forced apart in a horizontal direction; and, with a gradual increase of the pressure, the bolts of the horizontal joint were sheared, and the ring-flanges torn out, so that the tubbing no longer remained tight. On the flow of water increasing, it was decided to insert an additional ring for making the tubbing tight; and accordingly exact measurements were taken in the shaft for the construction of this ring of the largest possible diameter, with the object of retaining the existing large winding-cages and keeping the pumping-engine at work with a minimum of alterations.

This ring consisted of 8 segments, for the most part of cast-iron, but of cast-steel where there was only room for a slight thickness. While the ring was being inserted, however, it was soon seen that a further displacement of the tubbing had taken place, and the flow of water increased to about 770 gallons (from 3 to 4 cubic metres) per minute. It was especially difficult to insert the last segment, as it had to be fitted to a template. Ultimately the breach was tightly closed, the work being regarded as well performed.

Five years afterwards, however, a further displacement made itself manifest, as the closing ring was no longer tight; and it now appeared necessary to insert a column of cast-iron tubbing rings, 49 feet (15 metres) high, at the place where the breach occurred, a measure that had not been adopted before because it was feared that such supplementary tubbing would also give way on the thrust continuing and increasing. This new inside tubbing, 2·76 inches (7 centimetres) thick, was made to an inside diameter of 9·2 feet (2·8 metres), determined by the space inside the old closing ring, which it was not desirable to remove, because in that case the inburst of water would render the work very difficult, if not impossible. The column consists of 9 rings each, divided into 6 segments 4·9 feet (1·508 metres) high, and 2 wedging-cribs 11 inches (28 centimetres) high. The reduction that would thus be made in the cross-section of the shaft rendered it necessary to substitute a 4 decked cage with 1 tub on a deck for the previous 2 decked cage with 2 tubs on each deck.

For putting in the timber bed to carry the new tubbing, a working platform was erected, and perforated with holes because the shaft was a down-cast. The timber bed, of inverted internal conical form, was built between 6 horizontal feathers and flanges of the original tubbing, in order to give a sufficient bearing to the wedging-crib and to well distribute the weight of the new lining. The inside diameter of the lower wedging-crib is 3·1 inches (8 centimetres) less than that of the new tubbing; and the holes in the former were drilled while it was being erected in the shaft, after the first ring had been secured, the excess of metal being chipped off. In order to afford a better hold to the cement-concrete run in between the two tubbings, each of the four lower rings of the inside tubbing had 4 slightly projecting feathers cast on the outside. The joints were made with sheet-lead; and the water running from the breach, intercepted by a water-ring, was led down in pipes. Each segment of the fourth ring was cast with a hole, at first left open, but afterwards closed by a screw-plug. The fourth ring was surrounded with cement-concrete and covered with sand, when the water-ring was removed, to permit of the erection of the fifth ring, which came opposite the middle of the breach. There were 12 holes in this ring, so that the water might flow away by 18 holes altogether, and therefore not rise behind the inside tubbing. The sixth ring, which also had 6 water-holes near the bottom, was then erected and cement-concreted, after which the remaining rings were added successively and backed with cement-concrete. The upper crib, consisting of 6 segments, was inserted, screwed up, wedged and backed with cement-concrete, being also tightly wedged against the upper strengthening ring of the old tubbing. For safety's sake, a tightly-fitting timber ring was laid over the wedging-crib and secured by 80 cleats, bevelled off upwards, against two feathers of the old tubbing, so that in this case also further wedging might be effected in case the cement-concrete should allow water to pass. After the cement-concrete had set sufficiently, the 24 water-holes were gradually closed by screwing in plugs, and the water-

pressure came upon the whole tubbing, high-pressure valves being inserted in the last 3 holes to be closed, so as to permit of the closing being effected easily and thoroughly. J. W. P.

INTERCEPTION OF WATER FALLING DOWN SHAFT.

Charbonnages d'Abhooz et Bonne Foi-Hareng, Nouveau Siège de Milmort: Etablissement d'un Revêtement Métallique pour recueillir les Eaux. By — VRANCKEN. *Annales des Mines de Belgique,* 1899, *vol. iv., pages* 363-367, *with figures.*

When communication was effected between the Milmort pit and the Collard shaft, the latter (formerly used for winding) had been divided into two compartments, one for a ladder-way and the other as an upcast pit; and for that purpose the shaft was surmounted by an air-lock, connected by a drift with the Guibal fan. The engine for driving this fan, and also a pumping-engine, were erected in the old winding-engine house, while the boilers were put in order and tested. For feeding the latter, as there was no water near the shaft, a reservoir was formed in the foundations of the old winding-engine; and at the bottom of the shaft, 213 feet (65 metres) deep, a pump was erected for forcing the mine-water to the surface, thus ensuring in a few hours the boiler-feed for a whole week. Winding could now be effected in the new shaft, which is circular, and 12·8 feet (3·9 metres) in diameter, were it not for torrents of water falling to the underground landing, which not only rendered all work difficult, and would have wetted the coal to such an extent that it could not be screened but also interfered with the workmen travelling. Inasmuch as tubbing would have been costly and would have involved too much delay, the following course was adopted:—

It was necessary, for a vertical height of 266 feet (81 metres), to prevent the water escaping from the sides of the shaft from falling in the form of spray over the whole cross-section; and this was effected by sheet-iron lining, behind which the water is collected in a channel (made water-tight like a wedging-crib), whence it is led by a pipe to the water-lodge. On three rolled joists was laid a circular frame, made of H-steel bars, over which were placed between the frame and the sides of the shaft, rail-ends almost close together, one end of which was bedded in the shaft sides and the other resting on the frame. Brick-work, laid on these rail-ends, was carried up to a height of 10 inches (25 centimetres) for receiving a second and similar frame, and again 3·9 feet (1·2 metres) above a third frame bearing on the second by means of four steel stanchions. Behind these two last-named frames were placed galvanized mild-steel plates 0·08 inch (2 millimetres) thick, bent to the circumference of the shaft, bolted together longitudinally, and hung to the frames by flat hooks rivetted to the plates. Cement-concrete was run in behind the plates up to half their height; but, as the mortar of the brick-work had been largely washed away, the cement of the concrete ran off; and in order to form a watertight bed, cloths coated with tallow were laid on the brick-work, a pipe being inserted in the cement-concrete for taking off the excess of water. The rest of the lining was made with similar plates, not bolted together but overlapping horizontally and vertically, the vertical laps breaking joint and being attached by hooks to frames as already described, while at intervals, for supporting a certain number of frames, fresh seatings were put in.

J. W. P.

CANALIZING WATER-COURSES FOR PREVENTING INFILTRATION INTO UNDERGROUND WORKINGS.

Note sur les Canalisations de Cours d'eau établies par la Compagnie des Mines de Roche-la-Molière et Firminy. By — GARAND. *Comptes-Rendus mensuels des Réunions de la Société de l' Industrie Minérale,* 1899, *pages* 65-72, *with* 8 *plates.*

The Roche-la-Molière et Firminy royalty is traversed by numerous water-courses, most of which flow over the outcrops of coal-seams, in which there are many old workings; and the gauging of several have shown that the infiltrations through the fissures are considerable, the water sometimes disappearing totally in summer after passing over certain outcrops. In order to reduce these infiltrations as far as possible, and therefore the quantity of water to be pumped, numerous and important canalization-works have been carried out since 1884, their total length amounting to 19,200 feet (5,843 metres), and the works being of two different types:—(1) Canalization with a watertight bed over the whole surface, and (2) the same with watertight banks for preventing lateral infiltration. The former consists in principle of forming an artificial bed of cement-concrete lined with cement, resting on a bed of puddled clay, for preventing infiltration, if the concrete should crack; and the latter consists in forming two banks of earth, faced with rubble masonry and backed with clay.

An example of each of these types is given, together with a table giving, year by year, from 1881 to 1898, the rainfall, the quantity of water pumped in the three divisions of the concession, and the works executed. An examination of the table shows clearly the advantage of the canalization-works. In the Malafolie division, the quantity of water pumped diminished considerably from 1886, owing to the deviation of the Ondaine stream, although the gauge showed a greatly increased rainfall; and the improvement was far more marked after the canalization of the Echapre in 1888. A comparison of the two rainy years 1891 and 1892 with two similar years before the works were carried out, namely, 1881 and 1882, shows that 35 per cent. less water had to be pumped for the two years together. On the other hand, a considerable increase in the water pumped from 1897 is due to the fact that two new feeders then showed themselves; and, if the quantity of water given by them be deducted from the above figures, the normal quantities of previous years will be obtained.

J. W. P.

WINDING-ROPES IN THE DORTMUND DISTRICT IN 1898.

Statistik der Schachtförderseile im Oberbergamtsbezirk Dortmund für das Jahr 1898. *By* W. M. *Glückauf,* 1899, *vol. xxxv., pages* 621-623.

Statistics published yearly since 1872 by the chief inspector of mines for the Dortmund inspection-district, with the object of increasing the degree of safety in shafts generally, and as regards travelling therein especially, show that the originally prevailing iron-wire rope has completely disappeared during the last three years.

Table A shows the satisfactory result that the number of breakages of ropes had diminished in 1898 as compared with previous years. Both the

ropes that broke last year were flat ropes made of mild steel, one of them close to the drum, after 187 days' use and having raised 35,510,000,000 kilogrammetres; and the other 820 feet (250 metres) below the pulley, after 246 days' use and raising 13,280,000,000 kilogrammetres.

TABLE A.—NUMBER OF BREAKAGES AND DISUSED WINDING ROPES.

Year.	Number of Collieries contributing information.	No. of Flat Ropes.				No. of Round Ropes.		Total Number of Winding-ropes Disused.	Breakage of Winding-ropes.	
		Steel.	Iron.	Aloe.	Hemp	Steel.	Iron.		No.	Per cent.
1872	59	1	28	9	1	6	69	114	22	19·30
1873	76	1	26	9	—	23	97	156	22	14·10
1874	92	4	30	14	2	42	106	198	19	9·60
1875	97	8	23	5	4	74	112	226	19	8·41
1876	91	11	11	6	1	85	103	217	15	6·91
1877	85	17	10	3	—	81	67	178	16	8·99
1878	90	28	3	5	—	102	64	202	19	9·41
1879	78	23	3	3	—	99	44	172	9	5·23
1880	79	19	2	8	—	106	35	170	8	4·71
1881	76	20	6	1	—	97	41	165	8	4·85
1882	89	25	4	4	—	126	35	194	15	7·73
1883	85	20	1	4	—	138	24	187	8	4·28
1884	85	30	—	3	—	139	18	190	6	3·16
1885	86	37	—	5	—	163	26	231	7	3·03
1886	95	33	—	3	—	161	7	204	5	2·45
1887	91	32	—	4	—	156	9	201	3	1·49
1888	101	45	—	1	—	201	2	249	9	3·61
1889	99	48	—	3	—	181	7	239	6	2·51
1890	96	45	—	2	—	196	3	246	5	2·03
1891	111	46	—	2	—	229	7	284	12	4·23
1892	96	52	—	1	—	210	1	264	5	1·89
1893	106	47	—	2	—	233	1	283	3	1·06
1894	101	54	—	—	—	231	1	286	4	1·40
1895	110	51	—	—	—	226	2	279	5	1·79
1896	105	39	—	—	—	231	—	270	5	1·85
1897	107	37	—	—	—	262	—	299	4	1·34
1898	116	53	—	—	—	316	—	369	2	0·54
Totals ..		826	147	97	8	4,114	881	6,073	261	4·28
Sudden Breakages, No. ...		48	19	7	0	81	105	260	—	—
Ditto, per cent.		5·81	12·93	7·22	0	1·97	11·95	4·28	—	—

The best results were shown by two ropes at No. III. shaft of the Bismark colliery, which were in use for 1,386 days and raised 1,179,200,000,000 kilogrammetres. These and other favourable results recorded are due partly to the excellent material from which the ropes are made and the method of manufacture, but chiefly to the well-designed construction of the winding-plant.

The length of service and performance of the locked-coil ropes taken out

last year tell more in their favour than do the figures of the previous year; and the flat-strand ropes lately introduced for winding appear to constitute a noteworthy improvement. The latter type of rope has been used since the end of 1897 in the inclined shaft of the Langenbrahm colliery, where, owing to the changing inclination (between 44 and 31 degrees) a rubbing of the rope against the timbering cannot be prevented. Whereas locked-coil ropes, previously used in that shaft, never lasted so long as 150 days, while no rope raised so much as 250,000,000,000 kilogrammetres, the two flat-strand ropes taken out at the end of 1898 had been in use 350 days, while one had raised 553,000,000,000 kilogrammetres and the other 590,000,000,000 kilogrammetres. Owing to the construction of the flat-strand ropes several wires of each strand come together outside, so that they wear equally; but in ordinary ropes it is only one wire of each strand that receives all the wear. The former also have the advantage that each wire remains for a comparatively considerable length on the outside of the rope; and therefore when it passes over the pulley, or is being wound round the drum, a long bearing surface is afforded for each separate wire.

TABLE B.—LIFE OF DISUSED WINDING-ROPES.

Description of Rope.	Days which the Winding-rope lasted.									
	0 to 200	200 to 400	400 to 600	600 to 800	800 to 1,000	1,000 to 1,200	1,200 to 1,400	1,400 to 1,600	Over 1,600	Total
Flat	20	24	6	3	—	—	—	—	—	53
Ordinary Round	53	63	66	73	24	5	8	4	5	301
Locked-coil	3	4	1	2	2	—	1	—	—	13
Flat-stranded	—	2	—	—	—	—	—	—	—	2
Totals	76	93	73	78	26	5	9	4	5	369

TABLE C.—EFFECTIVE WORK OF DISUSED WINDING-ROPES.

Description of Rope.	Effective-work in Milliards of Kilogrammetres.*										
	0 to 25	25 to 50	50 to 75	75 to 100	100 to 150	150 to 200	200 to 300	300 to 400	400 to 500	Over 500	Total
Flat	20	25	8	—	—	—	—	—	—	—	53
Ordinary round ..	68	49	35	50	40	13	14	5	3	10	287
Locked-coil	4	2	5	—	1	—	1	—	—	—	13
Flat-stranded ...	—	—	—	—	—	—	—	—	—	2	2
Totals	92	76	48	50	41	13	15	5	3	12	355†

* 1 kilogrammetre equals 7·233 foot-pounds. † No information respecting 14 ropes.

TABLE D.—REASONS FOR DISUSE OF WINDING-ROPES IN 1898.

Reasons for Disuse.	Flat Ropes.	Ordinary Round Ropes.	Locked-Coil Ropes.	Flat-Stranded Ropes.	Total.
Deficient resistance under test	1	20	—	—	21
Breakage of individual wires or strands	25	171	2	2	200
Generally worn out	19	50	1	—	70
Insufficient length	—	23	2	—	25
Destruction of the covering ropes and loss of shape	—	7	7	—	14
Period of use exceeded ...	—	4	—	—	4
Breakage of ropes	2	—	—	—	2
Alterations in general arrangements, etc.	6	26	1	—	33
Totals	53	301	13	2	369

Tables B and C show the time that the ropes have lasted which were disused during 1898, and the work performed by them. The reasons for the removal of particular ropes are shown in Table D. H. L. and J. W. P.

BENNINGHAUS REVERSING LEVER FOR WINDING-ENGINES.

Steuerhebel Patent Benninghaus für Fördermaschinen. By — STAPENHORST. *Glückauf*, 1899, *vol. xxxv.*, *pages* 317-318, *with drawings.*

In the Benninghaus arrangement, power is first exerted by the reversing lever acting on a very short lever-arm; and then, when pressure is taken off the valves, the lever-arm is increased automatically for giving the valves the necessary travel. For bringing this about the reversing-lever is made with two slots, and the sector with two curved paths, so that in its ordinary movement the lever, to which studs are fixed (travelling in the curved paths), draws up by links the reversing-rod, thus altering the length of the lever-arm.

J. W. P.

AUTOMATIC SHAFT-FENCES.

Barrières Automatiques pour les Burquins ou Balances. By C. LERMUSIAUX. *Publications de la Société des Ingénieurs sortis de l'École Provinciale d'Industrie et des Mines du Hainaut*, 1898-99, *vol. viii.*, *pages* 22-25, *with figures.*

The sliding fence that is often used at pit-banks—taken up by the rising cage and again left in place on its descending—has been modified so as to serve for underground landings. The brackets fitted to the bottom-rail of the fence, that are caught by the roof of the cage, are suppressed; and one of the round vertical rods on which the fence slides is made removable, so that the fence can turn like a door round the other left in place. Two straps are attached by bolts to the upper rail of the fence for receiving the ends of ropes that pass over sheaves, and the other ends are attached to a flat horizontal bar, hung at such a distance above the fence that the floor of the

descending cage will draw it down, and thus raise the fence sufficiently to allow of tubs passing, the parts returning to their original position on the cage again rising. When it is required to let down timber, the bolts of the straps are taken out and also the removable guide-rods, allowing the fence to swing vertically out of the way. J. W. P.

PREVENTION OF SHAFT ACCIDENTS.

Les Accidents Survenus dans les Puits pendant les Années 1896 *et* 1897. *By* VICTOR WATTEYNE. *Annales des Mines de Belgique*, 1898, *vol. iii, pages* 453-524 *and* 617-726, *with illustrations.*

For the purposes of this paper, accidents connected with shafts, which in Belgium (with a total number of 87,580 underground workpeople) amounted to 47, causing 28 deaths and 24 cases of serious injury, during the years 1896 and 1897, are divided into 10 categories, due to the following causes, to which the number of accidents is appended, followed by that of fatalities in parentheses:—Insufficient closing-in of cages, 8 (4); untimely or unexpected movement of cage, kibble, etc., 17 (5); insufficient fencing of landings, 5 (6); falls during inspection of and repairs to shaft, 6 (5); fall of hard substances down the shaft, 1 (0); breakage of ropes or connexions, 2 (2); drawing-up of the cage to the pulleys, 2 (2); use of the man-engine, 1 (1); underground steam-engines, 1 (3); and miscellaneous, 4 (0). Attention is, however, chiefly bestowed on accidents caused by insufficient closing-in of the cage, and those due to men getting on the cage-cover; and it is hoped that, at any rate, the direction is indicated in which reform should be effected for diminishing accidents.

In connexion with the first category of accidents, many arrangements for enclosing the cage are described—all of them susceptible of modification in detail to suit special cases—abundantly proving that the problem of effectually shutting in cages on all their sides is not insoluble, so as to place the workmen entirely out of danger in this respect; and it is claimed that these arrangements in no way interfere with any of the purposes to which the cage may be applied in addition to winding workmen under normal conditions. To sum up the principal characteristics of these cage-closing arrangements, the lateral faces of the cage must be closed by perforated plate or wire-gauze, having some of the panels left free for giving access to the signal-cord, and others that can easily be taken out for inspections and repairs, allowing the workmen to escape if the cage should stop elsewhere than at a landing, etc.; and the ends, or charging-faces, should be fitted with light doors easily moved, sliding vertically or rolling up like a window-shutter, or, again, folding back against partitions permanently fixed to the cage, so as to close the compartment, at any rate, up to the height of 2¼ feet (70 centimetres), the closure being completed if the cage is high by a fixed bar placed 1½ feet (50 centimetres) higher. Inasmuch as the doors may be opened at any time, from the outside as well as from the inside, the exit, if necessary, of the workmen in the cage is thus permitted by the ends as well as by the sides.

Many of the accidents that come under the second category are due to imprudence or clumsiness on the part of the victims or their fellow-workmen, or, again, to too great precipitation in moving the cage, which is the almost inevitable consequence of continually increasing the output by the same shafts, requiring very rapid working of the cage. It is, therefore, desirable that no action in connexion with loading or unloading be effected, and that no one be permitted to enter or leave the cage before the latter is down upon the keps,

or has come to rest, because there are collieries where the caging is performed without keps, which are, moreover, taken out from landings no longer used.

Two of the accidents recorded in the third category would not have been prevented by most of the arrangements proposed, and, indeed, recommended by the French Ministerial circular of May 2, 1892, although they might, on the contrary, have been prevented by the Mauerhöfer lattice-work doors, which are double for each shaft-compartment and slide forward one towards the other on rails inclined so as to form a letter V in plan, so that, when left free, they completely close the compartment; but on the cage passing (which is fitted with a special frame terminating above and below in projecting elongated wedges) they are separated and kept apart until the cage has passed. Several shaft-closing arrangements used in Westphalia are described, which not only keep the landings closed when the cage is not there, but also prevent any inopportune movement of the cage while the tubs are being run on or pushed off.

As to inspecting and repairing the shaft, one of the accidents recorded under this head gave rise to an official inquiry in Belgium for ascertaining whether the practice of workmen getting on the cage-cover is necessary, or whether some less dangerous manner of inspecting the shaft cannot be adopted; and the following are some of the recommendations made in consequence:—The men should not get upon the cage-cover except in cases of absolute necessity, and should be provided with a safety-belt and a movable shield attached to the winding-rope for protection against falling stones. The cage-cover should not have a dangerous slope, and it should also be surrounded by a sufficiently high rail; and, when the signal cord cannot be worked easily, the banksman should keep his hand on it, so as to feel the slightest pull. The safety-belt, although generally recommended, has the disadvantage that it necessarily connects the man wearing it with the rope, etc., to which he may be attached, thus depriving him of all chance of escape in the event of an accident happening to the object to which he is attached, while it interferes with his movements and prevents him from escaping in the event of unforeseen danger. The author would not, however, prescribe safety-belts altogether, but only limit their use to cases where other means cannot be substituted.

A large proportion of the accidents coming under the fifth head, namely, the fall of hard bodies down the shaft, were attributed to the use of flying scaffolds of rough and insecure construction, while there are several of good design that may be employed.

Accidents due to breakage of rope are left for special consideration in a separate paper; and as to overwinding, the author recalls a former remark of his, that in any case well-designed head-gear of great height, and fitted with guides gradually brought nearer together above the bank, afford a safeguard against accidents due to this cause, although it is evident that the construction must be sufficiently strong to effectually retain the cages. J. W. P.

LOCOMOTIVE HAULAGE IN AMERICAN MINES.

Mechanical Mine Haulage. ANON. *Engineering and Mining Journal* [*New York*], 1899, *vol. lxviii., pages* 218-219, *with illustrations.*

The steam locomotive continues in use in some of the larger collieries in Pennsylvania and elsewhere, but the objections to its use are obvious.

The electric locomotive is built in very compact form, and adapted to all mine-galleries except the very smallest. The usual custom is to use a bare copper wire to carry the current, and, in practice, the danger involved in this is less than might be expected. There are several types of electric locomotive for use in mines. One of the Baldwin-Westinghouse type was built for the Berwind-White Coal-mining Company. The motive power is furnished by two 50 horsepower single-reduction motors (of slow-speed tramcar type), one geared to each axle. The driving-wheels are 30 inches in diameter, and the axles spaced 4 feet apart between centres. The total weight, ready for service, is 25,800 pounds, all of which is carried by the driving-wheels. The journals are unusually large, being 4 and 6 inches in diameter, and carefully protected against dust. There is a rheostatic controller. The extreme height of the locomotive is 41 inches; width, 55½ inches; and length, 164 inches. The drawbar-pull is 4,300 pounds at 8 miles an hour on the level, and this has been exceeded in practice. The electric current is taken through a trolley-wheel from an overhead conducting-wire. The gauge of the track is 3 feet, with an extreme width of 3 feet over all.

At present, the most formidable rival of the electric mine locomotive is the compressed-air locomotive, which has proved its efficiency in many places, and is worth careful attention from mine-managers. In a four-cylindered compound engine of the Vauclain type, the air is carried in the storage-tanks (which take the place of the boiler on a steam-locomotive) at a pressure of 600 pounds per square inch, and is supplied to the cylinders at a working-pressure of 200 pounds per square inch. There are three air-tanks, two storage-tanks, 31 inches diameter, one being 13 feet 7½ inches long, and the other 11 feet 4½ inches long; and the third tank is 7 feet 4 inches long and 8 inches in diameter. The high-pressure cylinders are 5 inches and the low-pressure 8 inches in diameter, both being of 12 inches stroke. The valves are of balanced-piston type. The cylinder-covers are corrugated, in order to accelerate the dissipation of heat. On each side the piston-rods of the high-pressure cylinders and low-pressure cylinders are connected to a single cross-head. The driving-wheels are 24 inches in diameter and spaced 4 feet apart between centres, the short wheel-base enabling the engine to take sharp curves. The limits of size in this engine are:—Height, 6½ feet; length, 14 feet; and width, 6 feet 4 inches. The total weight, ready for service, is 22,000 pounds, all of which is carried on the driving-wheels. Since it is necessary to have sufficient storage to charge the locomotive almost instantaneously, it is customary to extend the pipe-line sufficiently far into the mine, so that it may act as a reservoir, and, at the same time, afford charging-stations at convenient points. This engine has hauled 32 cars, each weighing 1 ton, up a grade of 1·66 per 100. The first locomotive of this type proved so satisfactory that several others have since been built. The author quotes cases, and affirms that, in practice, the compressed-air locomotive has given efficiencies of over 50 per cent for the entire system. X. Y. Z.

AN IMPROVED ORE-SKIP.

By A. A. Hayward. *Journal of the Mining Society of Nova Scotia*, 1899, *vol. v., pages* 44-46.

The author, having had an average amount of experience with the old-fashioned and other ore-skips, and never having been satisfied with them, decided that, in the equipment of the Golden Group mine at Montague, he

would build one on entirely new lines. The construction and operation of this skip is somewhat of a new departure. The box is constructed of $\frac{3}{16}$ inch steel, built on 3 inches by 3 inches angle-iron, rivetted with ½ inch rivets, the size being 30 inches by 36 inches by 60 inches, and a capacity of about 37 cubic feet. On the inside, at both top and bottom, there is a band of ½ inch by 4 inches iron, securely rivetted to the sides of the skip, and to the angle-iron in the corners. This serves to keep the body of the skip square, and also takes up the wear occasioned by receiving and discharging the load. On the bottom there are two steel doors 15 inches by 36 inches by ½ inch. These doors are strengthened by strips of steel ¾ inch by 6 inches, and are securely fastened to the bottom of the skip on each side by three hinges on each door. As the doors have to withstand the entire shock due to the dumping in of the rock, both doors and hinges are made very strong. The hinges are made of 1 inch by 5 inches Swedish iron, and run entirely across the doors, to which they are fastened with ¾ inch rivets. Across the doors, running lengthwise, are two axles, each 2 inches by 2 inches, and extending 2 inches on each end over the ends of the door. These ends are turned down to 1½ inches, so as to receive the ends of the connecting-rods. These rods, four in number, two on each door, or one at each end, are made of 2½ inches by ½ inch iron, and are about 2 feet long. These rods on the other end are connected with the side-rod, or bail, which passes up on two sides of the skip, and is held loosely in position by two clips on each side. These clips are made of ½ inch by 4 inches iron, and are bolted to the body of the skip by ten ½ inch bolts—bolts being used so that the clips may be removed at any time when it is desired to remove the bail. This bail, or side-rod, is made of ½ inch by 5 inches iron, and extends about 2 feet above the skip. The two bails, or strips, are connected across the top by a ¾ inch by 6 inches piece, which is morticed into the side-rods. The top ends of the side-rods are connected to a ring in the centre, to which the hoisting-rope is attached. On the sides there are two sets of guide-shoes, made of 3 inches by 3 inches angle-iron, and faced with $\frac{5}{16}$ inch by 6 inches plate. Inside of the guide-shoes, and fastened to the side of the skip, are pieces of hard wood 2 inches thick, 2 feet long, and 6½ inches wide, forming a rubbing-board, to take up the wear of the guides, these guides being made of 4 inches by 6 inches spruce.

It will be seen that the load and skip are raised by a direct pull on the doors, and that it is impossible for the doors to open while the skip remains suspended. When the skip is hoisted to the surface, and sufficiently high to admit of a car being run underneath, a set of clutches engage the sides of the skip, holding it securely; the engineman then slacks back the cable, and the weight of the load forces down the doors, pulling down the side-rods at the same time. The material being discharged, the engineman hoists, the side-rods move up, the connecting-rods close the doors, and the skip is ready for another descent. The entire arrangement is nearly automatic, and has given every satisfaction. X. Y. Z.

SELF-LIGHTING MARSAUT LAMP.

Note sur une Lampe Marsaut à Benzine et à Rallumeur. By — LAFFITE. *Comptes-Rendus mensuels des Réunions de la Société de l'Industrie Minérale*, 1899, *pages* 112-117, *with* 3 *plates*.

Inasmuch as trials, continued for more than a year, have shown that lamps burning benzine possess great advantages over those burning oil, while also

being appreciated by the workmen, the author set about designing a safety-lamp to burn benzine, the use of which might be permitted by the French Mine Administration.

As it was desired to preserve the Seippel self-lighter, which is placed above the reservoir, the latter has nearly the same arrangement as in the lamps used at Westphalian collieries; but it is made of sheet-iron instead of malleable cast-iron, and lower and of larger diameter, for receiving the rack that forms part of the locking arrangement. The bottom is of brass; and in the middle of the cup there is a small cylindrical brass cage containing the wick-carrier and screw for working it. The screw-shank, contained in a small brass tube, terminates, underneath the bottom, in a milled head, which permits of working it from the outside. The oil-vessel is filled with cotton-wool, and is traversed by a small tube carrying the rod for working the self-lighter by a key at the bottom. The round wick, of plaited cotton, is drawn rather tightly through the wick-holder; and the end is unravelled for affording better contact with the layer of cotton-wool at the bottom of the oil-vessel. The lamp may be used for 12 months without the wool being renewed, except the small layer at the bottom of the oil-vessel, which should be changed every 3 months. The wicks would last indefinitely if they did not become dirty; but for that reason it is better to renew them every year. A good benzine or petroleum-spirit should be chosen for ensuring proper working; and one of about 0·7 density, boiling at a temperature of 136° to 248° Fahr. (between 58° and 120° Cent.), gives good results. The spirit is introduced by a small funnel, and the excess must be poured off, ½ ounce (15 grammes) of wool absorbing 4½ ounces (135 grammes). The consumption per hour is under 0·16 ounce (5·58 grammes), while the lamp can burn for 28 hours with an inch (25 millimetres) flame. No smoke is produced; the gauze does not become fouled, and the glass is almost as clean at the end of a shift as at the beginning, so that the lighting-power is almost constant. The complete lamp weighs 3 pounds 7½ ounces (1,575 grammes), or filled ready for use 3 pounds 12 ounces (1,710 grammes).

With petroleum-spirit, this lamp is far more sensitive to fire-damp than one burning oil; and on turning down the flame it is possible to detect ½ per cent. of fire-damp, while a 1 per cent. gas-content gives a cap about 0·16 inch (4 millimetres) high, which is perfectly visible. It is found that the addition of a shield to a lamp having a single gauze improves the illuminating-power, but that the addition of a second gauze to a lamp already having one and also a shield reduces the illuminating power by about 18 per cent.

An hour's lighting by the Marsaut lamp burning benzine costs 0·0347d. (0·00347 franc) against 0·0374d. (0·00374 franc) by one burning oil, thus showing a saving of 7 per cent. in addition to the improved lighting. At the Lens colliery, the oil-vessels are filled in an isolated lamp-room, as certain precautions must be taken; but there is no danger after the cotton-wool is drained and the plug screwed up. On account of the intensity and especially the uniformity of the light, with the facility of re-lighting, this lamp is asked for by the workmen; and it appears to afford as high a degree of safety as an oil-fed lamp. J. W. P.

SÜSSMANN ELECTRIC-LAMP FOR MINES.

Note sur la Lampe de Mines, Système Süssmann perfectionné. *By* JOSEPH GOFFIN. *Revue Universelle des Mines*, 1899, *vol. xlvii, pages* 257-263, *with* 1 *plate.*

Some important modifications suggested by practical experience have been made in the Süssmann electric lamp. The first change consisted in introducing the accumulator at the top instead of at the bottom of the box; and for this purpose the box, made of tin-plate, is cut near the top into two parts, which are connected by soldering over the joint a strip of tin-plate after the accumulator is put in place, the opening being effected by simply tearing off the strip.

It was, moreover, soon perceived that the lamp was far from standing the rough usage of collieries, and in the new form all the rigid parts of the accumulator are replaced by flexible substances, an indiarubber receptacle being substituted for that of ebonite, and a specially-shaped indiarubber cover for the wax-cement joint, the connexion between the cells and between the latter and the lamp-terminals being quite flexible, and only the parts connected with the switching on and off of the light remaining rigid. While the mounting of the incandescent lamp itself has been modified, a special arrangement of interruptor permits of handing the lamp, closed but not lighted, to a workman, thus saving nearly $\frac{3}{4}$ hour in the period of lighting.

The Belgian Mine Regulations prohibit the use of an external switch, so that the workman cannot switch the light off and on underground; and, again, present methods of locking are not sufficiently rapid to obviate the necessity of preparing and therefore lighting in advance a large number of lamps, thus uselessly increasing the period of lighting. The new arrangement permits of only switching on the light when the lamp is handed to each workman, or, if it be preferred, to let each man switch on the light, at the moment of going down, by simply giving a last turn to the screw which completes the closure, while at the same time affording a simple connexion between the two parts, turning one upon the other for opening or closing.

The improvements made appear to have met the requirements of practice; and even some lamps crushed between tubs have continued to give light. The arrangement for charging the accumulators have also been improved, in order to save time; and arrangements are being adopted so as to permit of charging the lamp so soon as handed in, without the necessity of waiting until each series of 20 lamps to be charged is completed.

J. W. P.

ELECTRICALLY-DRIVEN CAPELL AND MORTIER FANS AT THE UNITED BONIFACIUS COLLIERY.

Vergleichende Untersuchung der Wirkungsweise der beiden elektrisch angetriebenen Ventilatoren, System Capell und Mortier, auf Zeche ver. Bonifacius bei Kray. ANON. *Glückauf*, 1899, *vol. xxxv., pages* 886-892, *with* 2 *plates.*

The rather rare opportunity of being able to work two fans under the same conditions, and thus to compare their efficiency, is afforded by the electrically-driven ventilating appliances of the Bonifacius pits, at Kray, where a Capell fan (1893) and a Mortier fan (1896) have been erected side by side. The plant consists of three separate parts:—(1) The generating-station, with steam-engine and dynamos; (2) the conducting-cable; and (3) the secondary station, with three motors and the two fans.

TABLE SHEWING RESULTS OF EXPERIMENTS ON ELECTRICALLY-DRIVEN CAPELL AND MORTIER FANS AT THE UNITED BONIFACIUS COLLIERY.

No. of Experiment.	Name of Fans.	Conditions of Experiments.	Electrical Efficiency of the Generating Dynamo. Kilowatts. $\left(Kw = \frac{V.A}{1000}\right)$	Volts. (V)	Amperes. (A)	Volume of Air per minute (Q)	Observed Water-gauge. (h)	Revolutions per minute. Steam-engine. (n)	Dynamo (n′)	Motor or Fan. (n″)	Electrical Efficiency of the Dynamo $\left(Nth = \frac{KW}{0{\cdot}736}\right)$	Effective Power of the Fan. $\left(Ne = \frac{Q.h}{60.75}\right)$	Theoretical Water-gauge. $\left(H = \frac{u^2 \gamma}{g}\right)$	Manometric Efficiency. $\left(\frac{h}{H}\right)$	Equivalent Orifice. $\left(a = \frac{0{\cdot}38.\ Q.}{60.\ \sqrt{h}}\right)$	Efficiency of Plant. $\left(\frac{Ne}{Nth}\right)$
								SERIES 1.—Constant Water-gauge.								
		Water-gauge.				Cubic Metres.	Millimetres.				Horsepower.	Horsepower.	Millimetres		Square Metres.	
1	Capell	79	43,000	1,075	40	2,703	79	60	383	226	58·45	47·45	154·15	0·51	1·92	0·81
	Mortier	80	43,000	1,075	40	2,642	81	57	378	206	58·48	48·46	111·57	0·73	1·89	0·83
2	Capell	75	38,950	1,025	38	2,629	75	57	385	219	52·92	43·82	144·75	0·51	1·92	0·88
	Mortier	75	38,220	980	39	2,572	75	55	363	198	51·93	42·86	108·07	0·73	1·87	0·82
3	Capell	70	35,400	985	36	2,597	70	55½	376	215	48·10	40·40	130·61	0·50	1·96	0·84
	Mortier	70	34,687	925	37·5	2,430	70	51	350	190	47·13	37·80	94.91	0·74	1·84	0·80
4	Capell	60	29,920	880	34	2,444	60	52	355	201	40·65	32·59	121·98	0·49	1·90	0·80
	Mortier	60	27,880	820	34	2,313	60	48	328	179	37·88	30·84	84·24	0·71	1·89	0·81
5	Capell	50	22,500	750	30	2,227	50	48	328	180	30·57	24·74	97·79	0·51	1·99	0·81
	Mortier	50	21,700	700	31	2,108	50	44	296	159	29·48	24·41	66·47	0·75	1·80	0·79
								SERIES 2.—Constant Speed of Steam-engine.								
		Revolutions of Steam-engine.														
1	Capell	59	43,000	1,075	40	2,663	78	59	394	225	58·43	48·16	152·78	0·51	1·91	0·79
	Mortier	56	41,000	1,025	40	2,648	80	56	373	205	55·71	47·08	110·49	0·72	1·87	0·85
2	Capell	55	33,250	950	35	2,507	66	55	374	209	45·18	36·76	131·83	0·51	1·95	0·81
	Mortier	55	38,220	980	39	2,572	75	55	363	198	51·93	42·86	108·07	0·73	1·87	0·82
3	Capell	50	26,560	830	32	2,319	57	50	345	194	36·09	29·37	118·59	0·50	1·94	0·81
	Mortier	50	30,530	860	35·5	2,406	65	50	345	187	41·48	34·75	91·29	0·71	1·89	0·84
4	Capell	45	19,500	700	28·5	2,062	46	45	307	171	27·11	21·08	88·22	0·52	1·98	0·78
	Mortier	45	24,000	750	32	2,120	54	45	307	168	32·61	25·44	74·20	0·73	1·83	0·78
								SERIES 3.—Constant Supply of Electric Power.								
		Kilowatts														
1	Capell	40	39,690	1,050	37·8	2,575	70	55	380	213	53·93	40·06	136·93	0·51	1·95	0·74
	Mortier	40	40,000	1,000	40	2,600	78	54	362	200	54·35	45·07	105·16	0·74	1·86	0·82
2	Capell	35	35,100	975	36	2,511	67	55	375	213	47·69	37·39	136·98	0·49	1·94	0·78
	Mortier	35	35,150	925	38	2,552	75	53½	358	198	47·76	42·53	108·07	0·73	1·87	0·89
3	Capell	30	29,920	880	34	2,444	60	52	355	201	40·65	32·59	121·98	0·49	1·99	0·80
	Mortier	30	30,175	850	35·5	2,341	63	49	330	180	40·99	32·77	85·18	0·74	1·87	0·80
4	Capell	25	25,100	810	31	2,282	55	50	341	190	34·12	27·28	108·95	0·50	1·90	0·79
	Mortier	25	25,125	750	33·5	2,208	55	46	309	170	34·14	26·99	75·98	0·72	1·88	0·79
5	Capell	20	19,950	700	28·5	2,068	46	45	307	171	27·11	21·09	88·22	0·52	1·98	0·78
	Mortier	20	20,130	660	30·5	2,057	47	42	287	155	27·35	21·48	63·16	0·75	1·90	0·79
6	Capell	15	15,340	590	26	1,868	40	42	285	154	20·84	16·78	71·58	0·56	1·89	0·80
	Mortier	15	15,125	550	27·5	1,891	36	36	259	158	20·55	15·19	50·07	0·72	1·99	0·78

(1) The steam-engine has a single cylinder 20·47 inches (520 millimetres) in diameter and 31·50 inches (800 millimetres) stroke, working without condensation, at a pressure of 65 pounds per square inch, with a normal velocity of 45 revolutions and a maximum velocity of 60 revolutions per minute. The engine developed 64·4 horsepower at 60 revolutions. The fly-wheel, 13·12 feet (4 metres) in diameter and 19·68 inches (½ metre) broad, transmits the power by means of 5 hempen ropes to a lay-shaft, in the ratio of 1 to 4. The power is taken off the latter by means of belting in the ratio of 1 to 1·67, so that the generating-dynamos can thus be driven independently. Accordingly, when the engine is working at 60 revolutions the dynamos make about 400 revolutions per minute. The continuous-current dynamos are capable of producing, at 430 revolutions per minute, a current of 42·5 amperes and 1,200 volts. The conductor to the secondary station, 3,937 feet (1,200 metres) distant, consists of 8 bare copper wires, having an area of 0·0527 square inch (34 square millimetres), coupled in pairs.

The motors and fans are erected close to the No. 3 shaft. The motors, at 200 revolutions per minute, yield 43 horsepower; and are so arranged that the two external ones can drive only the fan next to them, but the middle motor can drive either fan.

The Capell fan has a diameter of 9·84 feet (3 metres) and a breadth of 6·56 feet (2 metres). The Mortier fan has an external diameter of 9·18 feet (2·8 metres) and 18 vanes 4·07 feet (1·24 metres) broad. The observations were made in December and January, 1898-99, during favourable weather, in which the barometer showed no considerable fluctuations. They were made on Sundays, holidays or at night, whilst no coal was being drawn and no workmen were in the pit.

The calculation of the motor-efficiency of the ventilators could not be performed with the accuracy that might be desired, as the work transmitted from the motor to the fan could not be directly measured, there b ing no suitable instruments for electrical measurements at the secondary station. Accordingly, the current-quantity and tension were measured at the generating-station. The motor-efficiency (Ne ÷ Nth) refers accordingly to the ratio of the effective work rendered available by the fan to the work performed by the generating dynamo; so that the loss of tension in the conductors and the resistance in the secondary motor are not separately taken into account. As, however, the same primary dynamo and secondary motors were used throughout, the calculated values may serve for a comparison of the two fans.

Three series of experiments were undertaken: (1) Both fans were made to work so as to produce the same water-gauge; (2) both fans were run with the same number of revolutions of the steam-engine; and (3) the fans were so driven that the generating dynamos supplied both fans with an equal number of watts. The main results of these three series of experiments are shown in the annexed table.

The general result of the various experiments may be summarized in the statement that, under the conditions existing at the Bonifacius pit, the Capell fan gave the same quantity of air as the Mortier fan with a lesser water-gauge and required somewhat less power at a normal mean velocity. The Mortier fan, on the other hand, showed a considerably higher manometric efficiency, while the efficiency of both fans was about the same. The equivalent orifice of the Bonifacius pit was 20·88 square feet (1·94 square metres) when worked with a Capell fan, and 20·24 square feet (1·88 square metres) with the Mortier fan.

H. L.

FORCING VENTILATORS AT THE CONSOLIDATED SILESIA PIT, NEAR CHROPACZOW, AND THE CONSOLIDATED DEUTSCHLAND PIT, NEAR SCHWIENTOCHLOWITZ, IN UPPER SILESIA.

(1) *Die blasende Ventilation auf den Steinkohlengruben Cons. Schlesien bei Chropaczow und Cons. Deutschland bei Schwientochlowitz in Oberschlesien. By* BERGASSESSOR STEINHOFF. *Zeitschrift für das Berg-, Hütten- und Salinenwesen im Preussischen Staate*, 1898, *vol. xlvi., pages* 280-294, *with* 3 *plates.*

(2) *Ueber blasend wirkende Hauptventilator-Anlagen. By* BERGASSESSOR KETTE. *Glückauf*, 1899, *vol. xxxv., pages* 541-547.

The authors summarize the information up to the present available on the subject of fans employed for forcing air into the mine instead of exhausting it. The French Commission came to the conclusion that theoretically forcing ventilation had many advantages over ventilation by exhaustion, because the former required a little less power and produced a plenum of pressure which tended to keep back blowers of gas and choke-damp, and moreover, with a falling barometer, any more rapid evolution of such gases could be more effectually met by increasing the compression of the air in the mine, yet in practice, such forcing fans are seldom found, because in order to maintain the natural principle of ascensional ventilation such a fan would have to be situated at the deepest shaft, which would generally be the winding-shaft: this causes difficulties, whilst a ventilator acting by exhaustion may be placed at any shaft whatever, and need not take up space in the winding-shaft. Further, on any sudden stoppage of a fan working by exhaustion,. atmospheric pressure in the mine would naturally increase and thus offer greater difficulties to the escape of the mine-gases, whereas with a forcing ventilation the opposite is the case, which is all the more serious because the stoppage of a ventilator is always a critical moment for a mine. Nothing is said as to forcing ventilation favouring the production of gob-fires.

At this time, the possibility of placing a fan at the bottom of the shaft, and thus not disturbing the drawing of the coals in the shaft, seems not to have been considered. Since 1882, a large forcing Guibal fan, 22·96 feet (7 metres) in diameter has been in operation underground, upon which a full report by Mr. B. Otto has been published.* Mr. Richter, who put in this fan, had already obtained good results with a 9·84 feet (3 metres) Ritter fan, used in the same way, at the Johannes shaft, near Lugau, and selected it because large quantities of choke-damp were given off from the workings, and it was hoped that this might be kept back by the employment of forcing ventilation. According to Mr. Otto, the results of a forcing ventilation were favourable, but detailed proofs are wanting. Nevertheless, despite of his favourable opinion, such ventilators were subsequently but little used, although at No. 3 shaft of the Danube Shipping Company, at Fünfkirchen, in Hungary, an underground forcing Guibal fan, blowing 34,000 cubic feet (960 cubic metres) per minute, was put in operation in the year 1889.

At the Silesia colliery, a fan was erected in 1892 at the 541 feet (165 metres) level, another in 1893 at the bottom or 754 feet (230 metres) level, whilst at the Deutschland colliery both fans are situated at the 738 feet (225 metres) level, and not on the lowest or 984 feet (300 metres) level, one of these having been set to work in 1895 and the other in 1897. The results obtained by these different fans are indicated in the annexed table.

* *Trans. N. E. Inst.*, vol. xxxiv., *Abstracts*, page 49.

TABLE SHEWING EFFICIENCY OF FORCING FANS AT THE CONSOLIDATED SILESIA AND CONSOLIDATED DEUTSCHLAND COLLIERIES.

No. of Revolutions per minute.		Volume of Air per minute.		Water-gauge.		Natural Water-gauge of the Mine.		Total Water-gauge.		Indicated Power of the Engine.	Mechanical Efficiency	Equivalent Orifice of the Mine. Excluding Natural Ventilation.		Equivalent Orifice of the Mine. Including Natural Ventilation.		Work of the Fan. Excluding Natural Ventilation.	Work of the Fan. Including Natural Ventilation.
Engine.	Fan.	Cubic Metres.	Cubic Feet.	Millimetres.	Inches.	Millimetres.	Inches.	Millimetres.	Inches.	Horse-power.	Per cent.	Square Metres.	Square Feet.	Square Metres.	Square Feet.	Horse power.	Horse-power.
						A. CONSOLIDATED SILESIA COLLIERY. Fan in the 541 feet (165 metres) Level.											
130·0	130·0	695	24,550	4·0	0·15	5·0	0·20	9·0	0·35	—	—	2·20	23·6	1·46	15·6	0·57	1·30
150·0	150·0	910	32,150	6·0	0·23	5·0	0·20	11·0	0·43	—	—	2·35	25·2	1·74	18·8	1·21	2·23
						Fan in the 754 feet (230 metres) Level.											
55·0	104·5	1,000	35,350	9·0	0·35	6·5	0·26	15·5	0·61	7·00	28·5	2·11	22·7	1·61	17·3	2·00	3·45
70·0	133·0	1,300	45,900	14·0	0·55	6·5	0·26	20·5	0·81	14·00	28·8	2·20	23·7	1·82	19·6	4·00	5·92
85·0	161·5	1,406	49,650	17·0	0·66	6·5	0·26	23·5	0·92	23·00	25·1	2·16	23·2	1·83	19·6	5·31	7·35
						B. CONSOLIDATED DEUTSCHLAND COLLIERY. Mortier Fan for the Eastern Section.											
59·0	218·3	2,085	73,650	36·5	1·44	8·5	0·33	45·0	1·77	62·07	27·2	2·18	23·4	1·97	21·2	16·91	20·85
71·4	264·2	2,355	83,370	46·5	1·83	8·5	0·33	55·0	2·16	91·10	26·7	2·18	23·4	2·01	21·6	24·33	28·78
76·9	284·5	2,460	86,900	59·5	2·35	8·5	0·33	68·0	2·68	106·10	30·6	2·02	21·7	1·89	20·3	32·52	37·17
						Mortier Fan for the Western Section.											
60·0	124·8	1,080	38,150	33·0	1·29	7·0	0·28	40·0	1·57	19·82	39·9	1·19	12·8	1·08	11·6	7·92	9·60
75·0	156·0	1,351	47,700	50·0	1·96	7·0	0·28	57·0	2·24	34·95	42·9	1·21	12·9	1·13	12·1	15·01	17·10
84·0	174·7	1,427	50,400	61·0	2·40	7·0	0·28	68·0	2·68	48·64	39·8	1·16	12·5	1·10	11·8	19·34	21·60

With the exception of one Mortier fan, the three others are all centrifugal fans with 24 or 25 blades. The Mortier fan is 6·88 feet (2·100 metres) in diameter, that of the other fan at the Deutschland colliery 11·16 feet (3·400 metres), whilst the two fans at the Silesia colliery are respectively 8·20 and 9·18 feet (2·500 and 2·800 metres) in diameter.

It is seen from the table that the compression effected, especially on the Silesia colliery, is not very considerable, so that even now the natural ventilation of the mine plays a very important part. The result of the experiments with this fan seems to be that when the mine is connected to the surface through open workings or fissures, a portion of the air forced in by compressive ventilation makes its way through the old workings and ventilates them, so that any gases given off can no longer enter the mine, but are forced up to day through these fissures. Under similar conditions, ventilation by exhaustion would draw the foul air from the old workings into the mine, whilst fresh air would find its way down from the surface and be drawn up by means of the fan. In such cases, there seems no doubt that the method of compression is preferable. In the absence of any such communication with the surface, the plenum of pressure produced by a forcing fan will extend to all mine-workings, as also to the goaf and any fissures that may exist. The foul air will only be kept back in these until the plenum of pressure, which naturally diminishes as the distance from the fan is increased, is everywhere uniform. With ventilation by exhaustion, the diminution of pressure produced by the fan will also extend to the goaf as soon as equilibrium exists. In either case, the foul gases can only escape by diffusion. Variations of barometric pressure will have an equal effect in either case, but as the barometric pressure is apt to change abruptly and to a very considerable extent, it is obvious that with fans of only moderate power, such as all the fans that have been used up to the present, it is impossible to compensate for this.

Another forcing-fan was erected in the year 1897 in Westphalia, at the Glückswinkelburg colliery, near Bochum, where a forcing Capell fan of 5·74 feet (1·75 metres) diameter has been erected at the surface, forcing about 14,000 cubic feet (400 cubic metres) of air into the mine per minute, with an average of 60 revolutions and a plenum of pressure equal to about 1 inch (25 millimetres) of water. The object of erecting a forcing-fan in this case was that there are workings at various levels, and by putting a forcing-fan over the main entrance it was possible to use four air-drifts as return airways. In order to keep the air-current moving in the same direction, and to gain the benefit of ascensional ventilation, it would accordingly have been necessary in this case to have erected four separate smaller fans at the mouth of each of these smaller airways.

Exhausting fans have frequently been erected remote from the winding-shafts, at special air shafts, and therefore cannot be so readily got at. It may also be pointed out as an advantage of the forcing-fan that in the case of an underground fire the rescue-parties can work with a greater feeling of safety on account of the knowledge that they have the fan behind them, and therefore the road to the fresh air is always open.

It is suggested that in shallow pits which are connected with the surface by means of numerous cracks and fissures, forcing ventilation is preferable to ventilation by suction, and that a forcing-fan will produce a better effect upon the ventilation of the pit the greater the water-gauge due to it.

H. L.

THE PROBABILITY OF OUTBURSTS OF FIRE-DAMP.

Sur une Application du Calcul des Probabilités à la Fréquence des Dégagements instantanés de Grisou. By J. Beaupain. *With a preface and addendum by* Emil Harzé. *Annales des Mines de Belgique,* 1900, *vol. v., pages* 3-28.

With reference to the investigation undertaken by the Societé Belge de Géologie, de Paléontologie et d'Hydrologie, as to the influence of earth-tremors on the evolution of fire-damp, Mr. Harzé inquires as to the extent to which the alleged relationship between these phenomena is supported by official records of sudden outbursts of fire-damp or ignitions of that gas in Belgium. During the 30 years from 1869-98, comprising 9,000 working days, there were 3 days in which 2 sudden outbursts of fire-damp occurred, out of a total of 237 of such outbursts. During the same period, 2 accidents by ignition of fire-damp never occurred on the same day. To ascertain whether the 3 cases of 2 outbursts in one day were only the result of the law of probabilities the following problems were submitted to Mr. J. Beaupain:—Given an urn containing 9,000 numbers, out of which single numbers are successively drawn and returned to the urn after each drawing: In how many drawings is it probable (1) that at least one number will be drawn at least twice; (2) that at least two numbers will be drawn at least twice; (3) that at least three numbers will be drawn at least twice. The solutions of these three problems are respectively, 112, 175 and 222 drawings, all inferior numbers to that (237) of the cases of sudden outbursts of fire-damp. From which it is concluded that the rare cases of two sudden outbursts on the same day cannot support the idea of a common seismic origin. In an addendum, Mr. Harzé gives the results of an inquiry as to abnormal disengagements of fire-damp on the occasion of an earth-tremour on July 19th, 1899. Inquiries were made at 9 fiery collieries extending through the whole Belgian coal-field from west to east, these collieries comprising at least 43 important mines. The result was entirely negative, no unusual evolution of fire-damp having been observed.

W. N. A.

THE CAUSE OF IRREGULARITIES IN THE DETERMINATION OF FIRE-DAMP BY MEANS OF ITS IGNITING LIMIT.*

Note sur une Cause Apparente d'Erreur dans le Dosage du Grisou par les Limites d'Inflammabilité. By — Lebreton. *Annales des Mines,* 1899, *vol. xvi., pages* 95-104, *with* 1 *diagram in the text.*

This process for determining the percentage of fire-damp consists in determining the limits within which a non-combustible gas will explode when mixed successively with pure air and with the air containing fire-damp, to be tested. The difference between these two figures measures, by means of a constant, the proportion of marsh-gas in the air containing fire-damp.

It has often been found that inexplicable differences are at times obtained in making these tests. The author has discovered that these variations in the limits of inflammability depend entirely upon the inclination of the eudiometer in which the experiment is performed. He has found that, for a given angle, the limit of inflammability of each gas tried (coal-gas, fire-damp from a blower, and hydrogen) is absolutely fixed; that when the eudiometer-tube is inclined to the vertical, the limit of inflammability decreases rather

* *Trans. Inst. M. E.*, vol. ix., page 373.

slowly, until the tube makes an angle of about 43 degrees to the vertical, then more rapidly down to an angle of 83 degrees 45 minutes, beyond which it was impossible to go.

Inclination of the Eudiometer to the Vertical.		Coal-gas.		Hydrogen.		Fire-damp.	
		Limit of Inflammability per thousand.	Decrease of the Limit per thousand.	Limit of Inflammability per thousand.	Decrease of the Limit per thousand.	Limit of Inflammability per thousand.	Decrease of the Limit per thousand.
Deg.	Min.						
0	00	82	—	95	—	64	—
26	30	81	1	94½	0½	—	—
42	51	79	3	93	2	—	—
51	2	77	5	91	4	—	—
59	13	75	7	88	7	63	1
67	23	72	10	83	12	—	—
75	34	67	15	78	17	62	2
83	45	65	17	70	25	61½	2½

The preceding table shows the results obtained with an eudiometer containing 80 cubic centimetres. H. L.

FIRE-DAMP IN METALLIFEROUS AND OTHER MINES, BELGIUM.

De la Présence des Gaz Hydrocarbonés dans les Exploitations Souterraines des Minières et Carrières. By J. LIBERT. *Annales des Mines de Belgique*, 1899, *vol. iv., pages* 48-54.

It is not only in coal-mines that disengagements of fire-damp occur; but this gas is also met with, under exceptional circumstances and to a smaller extent, in the underground workings of metalliferous and clay-mines. The author has found records of the five following accidents due to the ignition of carburetted hydrogen in administrative documents relating to mine-workings in the province of Namur, in Belgium, where there are many iron-ore mines and clay-pits.

(1) The earliest case known (October 24th, 1860) occurred in the sinking-shaft, which had attained the depth of 24 feet (7·4 metres) of an iron-ore mine at Florennes. A workman, being let down the shaft, stopped at the depth of about 5 feet (1·5 metres) to light his lamp; but a violent explosion ensued, the flame of which, burning the man on the face, hands and right arm, rose 5 feet above the shaft-mouth. The gas is supposed to have been given off by some decomposing vegetable substance in an old working struck by the shaft.

(2) In an iron-ore mine at Saint-Aubin, a miner declared that, while taking a lighted lamp into a working 20 feet (6 metres) long, driven from the bottom of the winding-shaft, 59 feet (18 metres) deep, and on reaching the face he was thrown down by a fire-damp explosion.

(3) A similar but more serious accident occurred in a clay-pit at Coutisse. The winding-shaft was stopped at the depth of 125 feet (38 metres), and a heading had reached the length of 10 feet (3 metres) from the shaft, when a man, who had already bored two advance-holes, 30 feet (9 metres) deep, which encountered the timbering of an old working abandoned 8 years previously, was putting in a third hole, that had attained a depth of about 7 feet (a little

more than 2 metres), when the drill was expelled with violence, being followed by a disengagement of gas. Before the men could extinguish a naked light hung from the roof, the gas ignited, causing a violent explosion that seriously injured one of them.

(4) In a clay-pit at Wierde two shafts had been sunk, one to a depth of 89 feet (27 metres), in which a heading had been driven, ventilated by air-pipes surmounted by a funnel, and the other to 69 feet (21 metres), in which there was also a heading, but unventilated, as well as indications of old workings. In the last-named shaft, on a man putting fire to the gas, an explosion and the subsequent air-blast threw him down twice, the expansion of the gas being so great that the axle of the winch on the surface was thrown a distance of 7 feet (2 metres).

(5) The last accident of this nature officially recorded occurred on December 23rd, 1897, in a clay-pit at Braibant, where a workman was burned on the face and hands in a sinking-shaft 23 feet (7 metres) deep. At a place in the side of the shaft water with a bad smell leaked out, and subsequently the end of an old working was laid bare, exposing straw and timber. Nevertheless, a workman lighted his lamp and hung it up about 3 feet above the shaft-bottom; and the ignition of gas occurred soon afterwards.

It appears evident that the carburetted hydrogen disengaged in these outbursts was not of natural origin, but was probably due to the decomposition of timber and other organic matter in abandoned workings. The composition of these gases may be very complex, comprising in some cases sulphuretted hydrogen; and, owing to the impermeability of the clay-masses, the gas may acquire a certain degree of pressure, as was noted in one of the above-named cases.

Inflammable gas is not likely to be met with where there has been no previous working, notwithstanding the presence of lignite, which sometimes traverses the clay in the form of thin seams; nor can the fire-damp in clay-pits be attributed to the Coal-measures, seeing that the coal-seams in the Andenne basin, where most of the ignitions occurred, do not evolve any gas.

J. W. P.

FIRE-DAMP ACCIDENTS IN FRENCH COLLIERIES.

Analyse des Rapports Officiels sur les Accidents de Grisou survenus en France pendant les Années 1891 *à* 1897. *By* — Glasser. *Annales des Mines*, 1899, *series* 9, *vol. xvi.*, *pages* 137-189.

The elaborate tables, drawn up by the author, of all fire-damp accidents having caused personal injury or loss of life in French mines during the years 1891 to 1897, both inclusive, may be summed up in the annexed table.

Sufficient details regarding the circumstances which attended each accident, the state of the ventilation, etc., will be found in the remarks which accompany the tables. Moreover, the author draws attention to a number of accidents which he has not tabulated: for instance, during the years under review, 5 explosions were traced to ignition of dust, and claimed 18 victims, of whom 8 were killed and 10 badly injured. Six explosions (not tabulated above) were due to inflammation of the gases yielded by the slow distillation of coal: among these was the terrible disaster of Blanzy, in February, 1895, when 28 men were killed and 8 others injured. Suffocation by gases other than fire-damp swells the roll of the dead by no less than 34: of these 24

were asphyxiated at Rochebelle, in June, 1896, by a sudden outburst of carbon dioxide into the Fontanes pit.

Causes of the Accidents.		Number of Accidents.	Number of Deaths.	Number of Injured.	Total Number of Victims.
Inflammation of fire-damp produced by	explosion or ignition of a blasting-shot...	4	1	6	7
	naked lights ...	26	9	30	39
	safety-lamps opened, damaged or broken	10	4	13	17
	diverse causes, in particular, matches	3	62	13	75
	undetermined causes (dubious evidence tendered at enquiry)	3	1	3	4
Suffocation		5	5	0	5
Mechanical effects produced by a sudden outburst of fire-damp ...		1	2	2	4
Totals		52	84	67	151

Gloomy as they may be from one point of view, the author's statistics are encouraging from another point of view: they show the enhanced safety of human life in the French mines during 1891-1897, as compared with preceding years. The average number of deaths due to fire-damp figures out at 0·43 per million tons of output, and at 0·88 per 10,000 workmen *per annum*. This result is attributed in an official report, made to the French Ministry of Public Works, "to the increased precautions taken in fiery mines, to the growing progress in ventilation, to the use of safety-explosives, and to the ever more careful watching for fire-damp." L. L. B.

EXPLOSION AT THE CAROLINENGLÜCK COLLIERY, BOCHUM, WESTPHALIA.*

Die Explosion auf der Steinkohlengrube Ver. Carolinenglück bei Bochum am 17. Februar, 1898. OFFICIAL REPORT. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im Preussischen Staate*, 1899, *vol.* xlvii., *pages* 45-68, *and* 2 *plates*.

On February 17th, 1898, at 6.45 a.m., shortly after the day-shift had gone down the pit, an explosion took place at level No. 5 (1,110 feet) in the Carolinenglück colliery. It started with the ignition of a local accumulation of fire-damp, but its effects were so intensified by the presence of coal-dust that it resulted in one of the greatest disasters that have ever befallen the Lower Rhenish and Westphalian coal-field. No less than 116 lives were lost, and in addition 3 persons were badly injured.

* *Trans. Inst. M. E.*, vol. xvi., page 579.

The Carolinenglück colliery works almost exclusively the seams of the bituminous coal-group: the coal yields about 4 per cent. of ash, and reckoned apart from the ash, 25 per cent. of volatile matter. It is of a tolerably firm texture, and is mostly won by shot-firing with dahmenite A. The Coal-measures here are overlain by about 230 feet of Chalk Marl; owing to an over-thrust-fault, which has a downthrow of 260 feet, the field is divided into a northern and a southern district. The seams strike east and west, and have dips varying from 25 to 60 degrees. The colliery is worked by three shafts: one in the southern district going down to No. 4 level (785 feet) has been used since 1891 exclusively as an upcast shaft. The second, ½ mile farther north, going down to No. 5 level (1,110 feet) is used as a joint winding and downcast shaft for the northern and southern districts. The third, 160 feet distant from the second, goes down to No. 4 level, and is used as an upcast for the northern district.

In the northern district, the only one which need be considered in connexion with the explosion, the daily output sent to bank by about 470 work-people was 640 tons. The amount of fire-damp generally given off in the Carolinenglück colliery is small in comparison with that of other collieries in the neighbourhood: it is reckoned that about 175 cubic feet of gas are given off for every ton of coal drawn. As showing, moreover, how very moderate is the gassiness of these seams, it may be noted that, for several days after the explosion, despite complete chaos in the ventilation-arrangements, hardly any fire-damp could be traced in the pit. Blowers had certainly never been met with: yet, during the 10 years 1887 to 1896, no less than 8 ignitions of fire-damp had taken place, with a total loss of 2 lives and injury to 10 other persons. Temperatures in the pit were always comparatively low.

With regard to coal-dust, however, the author has quite another tale to tell. The seams, especially in the northern district, are dusty in the extreme; but, as the active association of dust with previous explosions had in no case being emphasized, it had not occurred to the management to adopt any system of spraying or watering the workings. It so happens that the workings in the eastern part of the northern district are excessively dry, while those in the western part are wet, but the water there comes from the stone, not from the coal.

The lamps in use were safety-lamps with a single gauze, internal igniters, and special locks. The oil burnt in them was rape, with a large admixture of petroleum, the result being that the lamps clogged very quickly, the igniters did not act properly, and so the workmen were often tempted to tamper with them: this was the more easy to do as the locks could be removed, and put back again almost unnoticed. After the disaster several of the workmen's lamps were found open, yet these had been delivered over to the men sealed and in good order, that very morning.

Shot-firing in the coal was always carried out with dahmenite A, dynamite being used only for blasting stone. Ordinary fuzes were employed, with fulminating caps, and were ignited by tinder, steel and flint. Shot-firers were specially told off to stem and fire the shots.

When the catastrophe took place most of the pitmen had barely reached the working-face, others were on the way thither, while the remainder were sitting down in groups and chatting. The atmospheric concussion extended far into the southern district, that is, beyond the winding-shaft. Throughout the area immediately affected by the explosion coke was found to have been formed, in all stages, from microscopically small beads, with which the floor was strewn, to great thick crusts; and indeed the actual course followed

by the enormous tongues of flame was indelibly mapped out by this coke-incrustation. Deposition of dust and soot took place over a far wider area than that covered by the coke. Throughout the whole of No. 4 and No. 5 levels in the northern district, and even 300 feet south of the winding-shaft, dust lay thick like velvet-pile on every plank and pipe and plane rock-surface. Some of the rescuers ran the risk of being choked by the dust stirred up as they groped along. It was proved by chemical analysis that this was not undiluted coal-dust, but that stone-dust was mixed with it: in colour it varied from dark brown to black, and yielded in some cases 32 per cent. of ash. Timbering was in many places shattered, splintered and scorched, brattice-cloths had been ripped down, rails torn up and twisted, and whole trains of tubs had been hurled along and tumbled into chaotic heaps.

All the probabilities point to the disaster having arisen as follows:—A hewer, provided with a safety-lamp, was working a ventilator by hand, when the flame from his lamp in some unexplained way blew through the gauze and ignited the fire-damp that was being ejected by the ventilator at a high speed. There is conclusive evidence that the chief agent in the further spread of the explosion was coal-dust and not fire-damp.

The doctors examined very carefully the bodies of 109 out of the 116 victims. In 58 cases they found no bones broken, but the exposed portions of the body (face, throat and hands) were scorched and blackened with coal-dust burnt into the skin. These deaths were evidently due to suffocation from want of oxygen. The explosion had so completely and rapidly exhausted the pit-air of oxygen that none of the victims were deeply scorched: the burns appear to have affected the epidermis only and not the epithelium, and clothes and hair were only slightly singed. In 14 cases there was injury to, or fracture of, bones, besides the burning of coal-dust into the skin: the victims were evidently hurled against timber or rock and knocked senseless. The remaining 37 cases were deaths due to poisoning by carbon monoxide or after-damp.

As a consequence of this disaster, the Prussian Government have formulated revised regulations for the Dortmund coal-field, and in regard to the Carolinenglück colliery, orders were immediately issued to suspend operations in the eastern portion of the northern district until such time as an organized system of water-spraying had been put in force. Meanwhile, even in the western portion, work was allowed solely on condition that the coal-dust should by some means or other be kept damp until a proper spraying-system was at work, and the latter must be ready in three months' time.

L. L. B.

UNDERGROUND PUMPING-ENGINES.

(1) *Neuere unterirdische Wasserhaltungsmaschinen für Bergwerke. By* B. GERDAU. *Zeitschrift des Vereines Deutscher Ingenieure*, 1899, *vol. xxxiii., pages* 29-36 *and* 57-65.

(1) The compound engine at the Hansa pit, Düsseldorf, is remarkable for the great height of the lift, and for the manner in which a water-feeder in the shaft is utilized. The engine is placed at a depth of 2,179 feet, and has the following dimensions:—High-pressure cylinder, 27·56 inches; low-pressure cylinder, 43·31 inches; air-pumps, 9·84 inches; ram-plungers, 4·13 inches; and stroke, 39·37 inches.

At 60 revolutions, 440 gallons of water are raised per minute to a height of 2,179 feet. The steam-cylinders are coupled at right angles, and each is fitted with its own air-pump and two single-acting ram-pumps. The water is raised from the sump 138 feet below the engine, or 2,317 feet from the surface (by a lifting set of pumps worked by a small two-cylindered water-pressure engine, driven by a water-feeder with a head of 1,092 feet) and delivered into a well in the engine-room, whence it is drawn by the suction-pipes of the air-pumps through the condensers, and passed into the suction-pipes of the main pumps under a pressure of about 7 feet, and is forced to the surface in a single lift through a rising main 7·72 inches in diameter. The suction of the main pumps is arranged so that any excess of water from the motor-column not required by the water-pressure engine can be passed in at full pressure. Steam is brought from the surface by an insulated pipe, 6·89 inches in diameter, at a pressure of about 75 pounds, both at the boilers and at the engine. The engine-room is 120 feet long and 27 feet broad.

(2) At the Piesberg colliery, near Osnabrück, the compound condensing engine is placed in an engine-room 128 feet long and 13 feet broad. It lifts 2,640 gallons to a height of 590 feet when working at 60 revolutions per minute. The pumps are 10·83 inches in diameter by 35·43 inches stroke. The consumption of steam, at a pressure of 6·8 atmospheres, was 17·50 pounds per indicated horsepower, and the engines developed 304 horsepower against 264 effective horsepower in the water delivered.

(3) At the Rheinpreussen colliery, near Homburg, there are two hydraulic short-stroke rotary engines. The hydraulic power is produced by a compound engine with cylinders 29·92 and 47·24 inches in diameter by 39·37 inches stroke, and four pressure-pumps 3·46 inches in diameter, running up to 55 revolutions per minute. The underground engine has three power-pistons, 4·13 inches in diameter, and three plunger-pumps 5·94 inches in diameter by 31·50 inches stroke, and at 60 revolutions has a piston-speed of 315 feet per minute. With 369¼ indicated horsepower 550 gallons of water are lifted per minute against a head of 1,519 feet, or 252 effective horsepower, showing a duty of 68¼ per cent. The pressure-pipe is 4·13 inches in diameter, the return-pipe is 4·53 inches in diameter, and the rising main is 9·84 inches in diameter. These hydraulic engines have been run for several days under water.

(4) An electric pumping-plant at the Zollverein colliery comprises a compound marine engine of 450 to 500 horsepower, driving a dynamo at 150 revolutions per minute, and producing 300 kilowatts at 1,000 volts. The continuous-current exciter, on the same shaft, develops 100 amperes at 110 volts; and a small exciter, driven by an independent steam-engine, is used at starting until the motor-engines have acquired their proper speed, and the main exciter takes over the entire work. The current is conveyed down the pit by two cables, each having three insulated copper conductors with a section of 0·279 square inches. The underground pumping-engine has two differential plunger-pumps, with rams 5·00 and 7·09 inches in diameter by 39·37 inches stroke, and the motor runs at 62 revolutions per minute. The surface engine, at 142 revolutions per minute, develops 426 horsepower, whilst the pumps at 60¼ revolutions lift 671 gallons to a height of 1,348 feet, equivalent to 278 effective horsepower, or a duty of 65¼ per cent. The consumption of steam is 15·5 pounds per indicated horsepower and 23·4 pounds per effective horsepower.

The following table shows the consumption of steam by various systems of pumping:—

Consumption of Steam per effective Horsepower per Hour.	Working continuously.	Working 12 hours per day.	Working 6 hours per day.
	Pounds.	Pounds.	Pounds.
Engines pumping by means of rods from surface ...	11 to 12	11 to 12	11 to 12
Underground steam-engines	10½	12¼	16¼
„ hydraulic engines	10	10	10
„ electrically-driven engines... ...	10·65	10·65	10·65

M. W. B.

(2) *Note sur la Machine d'Epuisement Système Kaselowsky.* By CHARLES FRANÇOIS. *Revue Universelle des Mines*, 1899, *vol. xlvii, pages* 152-164, *with plates.*

In the first applications of underground pumping-engines, the motive power of which is water under pressure, the only object was the utilization of a natural or artificial head of water; but when it was found that the transmission of power by water under pressure had many advantages, the number of applications increased. In a comparison between steam- and water-pressure pumping-engines, it may be concluded that their useful effect is practically equal, from 70 to 77 per cent. having been obtained in trials with steam-pumps at the collieries of La Louvière and La Paix, and with water-pressure pumps, 69 per cent. at the Pluto colliery and 74½ per cent. at the Gottessegen.

With respect to depth, as pits are deepened the temperature of the mine-water increases; and consequently when steam is used the condensation is more difficult and costly, a cause of lowering the yield of steam-pumps. Again, there is a limit to the power of an underground steam-engine, so that two or more must sometimes be employed instead of one, almost doubling the first cost; but with water under great pressure a single motor well proportioned can always be made to suffice.

The present tendency is to restrict more and more the dimensions of underground engine-rooms, especially in the case of loose or broken strata; and the water-pressure engine, by the simple arrangement of its parts, its compactness and the suppression of a fly-wheel, perfectly fulfils this condition.

With respect to the subdivision of power, small underground motors are sometimes necessary for mechanical haulage, exploring shafts, etc., while the use of rock-drills and mechanically-driven wedges for pushing forward stone-drifts, daily increases. Compressed-air requires an expensive installation, while giving out only a slight useful effect, and steam cannot be employed; but with water-pressure, all that is required is to lay down a branch pipe, that takes up little room owing to its slight diameter.

As regards certainty, the water-pressure pumping-engine will continue to work even if completely drowned; and it may be started from the surface.

In fine, the water-pressure pump may be regarded as having solved in a practical manner the problem of pumping from great depths. It affords a sufficiently high useful effect, does not require a large engine-room, does not heat the ventilating air-current (a point of importance in deep mines), does not encumber the shaft more than a steam-pump, and can work when

drowned. Although the plant is costly, this disadvantage is largely compensated by the great advantages of the system, especially in the case of deep and fiery mines. J. W. P.

UNWATERING THE COMSTOCK LODE, NEVADA.

By L. P. Gratacap. *Scientific American Supplement*, 1899, *vol. xlviii.*, *No.* 1,244, *page* 19,937.

An operation of immense interest to mining engineers has been in progress for the last 5 months in the district embracing the famous Comstock mines. The author refers to the remarkable circumstances connected with the discovery and development of this wonderful lode, the great difficulties of ventilation, owing to the great depth and temperature, and the practical loss of the mines eventually owing to the inflow of water. It was lately determined to make another attempt to unwater and again render practical the extended working of this invaluable lode. A plan has been accepted by which the water-level will be reduced 500 feet. The plant required was a stand-pipe extending from the surface to the required depth, terminating in an hydraulic elevator discharging into an elevator-pipe having its outlet into the Sutro tunnel. The force elevating the water is due to the pressure and velocity of the jet carrying a continuous flow to the point where it is discharged. The system is well-known to hydraulic engineers, but never before has it been employed in a task of such magnitude.

The elevation of the Consolidated shaft at the surface is 6,105 feet above sea-level, and its extreme depth is 2,900 feet. The water supplying the hydraulic elevator is ample in quantity and close at hand. The capacity of the ditch is from 150 to 300 miners' inches (of 1½ cubic feet each) per minute. The apparatus comprises a 12 inches steel pipe for the flow and a 15 inches steel pipe for the discharge. At a depth of 1,740 feet from the surface, or 100 feet below water-level, the first station was reached and the first pumping was done. The pressure at the jet was 1,136 pounds per square inch and the flow of water from the surface was 1,100 gallons per minute. At the first attempt, on February 20th, 1899, 8,000 gallons per minute were discharged into the Sutro tunnel, 140 feet above the jet. An investigation of all the shafts in the territory adjacent showed a reduction of the water-level, and flow from the most distant levels was clearly demonstrated. With the removal of water in the shaft, a new connexion, generally in 50 feet lengths, was added to both pipes. On April 5, 1899, the nozzle of the supply-pipe was enlarged, and measurements showed a discharge of 150 miners' inches, elevating 7,000 gallons per minute, the supply-pipe at the surface taking in 2,000 gallons per minute. The cost of the water from the ditch has proved to be less than 17s. or 4 dollars per day.

As the water had gradually lowered, access to the submerged mines was made practicable, and preparations for thoroughly prospecting the ground and for taking out the bodies of ore that were known to have existed when the lower workings were abandoned 12 years ago, had already commenced. It is not intended to operate the present system below the 2,100 feet level. At that depth, if the lower parts of the mines are opened, a permanent pumping-plant, driven by electricity, will be installed, and it is expected that the problem of ventilation will be solved by the same power. X. Y. Z.

GRÖNDAL-DELLWIK METHOD OF MAGNETIC CONCENTRATION OF IRON-ORES.

Magnetische Anreicherung von Eisenerzen nach der Methode Gröndal-Dellwik. By EDWARD PRIMOSIGH. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1899, *vol. xlvii., pages* 51-53.

The concentration of iron-ores and copper-ores has been a matter of careful study for many years at Pitkäranta in Finland. As the concentration of the former ore is of more general interest, its results only will be considered here, those upon copper-ores being passed over.

At Pitkäranta, magnetite is worked in large quantities. It is, however, so poor, and rendered so impure by the presence of sulphides, such as copper-pyrites and zinc-blende, that it is unfit for use unless these minerals can be separated. The iron-ore and the sulphides are moreover so finely disseminated that effective concentration is only possible when combined with very fine crushing. The percentage of iron in these ores is rarely above 25 per cent., but often falls below 20 per cent., whilst the ores are also exceptionally dense, so that two difficulties have in the first instance to be overcome:—(1) To crush the ore cheaply, and (2) to concentrate the powder successfully.

After several years of research, complete success has attended the experiments for this purpose, and a new concentration-works has already been built, which has been in operation for 10 months, treating daily 350 tons of ore. Experiments with rolls and ball-mills were unsuccessful, and finally a wet-crushing ball-mill was constructed. This consists of a cast-iron drum lined with chilled-iron plates, and provided with two large apertures on either side, through which the ore can be introduced and discharged. This construction presented the following advantages compared with the Gruson ball-mill:—Greater production with the same consumption of power, less cost of repairs and of working (about half), and ability to crush the ore in a current of water, by which means the production of dust is entirely prevented. Of the 8 mills now working at Pitkäranta, 4 are 68·89 inches (1¾ metres) in diameter, and 31·49 inches (0·8 metre) wide; the other 4 are about 78·74 inches (2 metres) in diameter, and about 39·37 inches (1 metre) wide. The former crush about 50 tons of moderately hard ore in 24 hours, with a consumption of 8 horsepower; the latter are designed for the crushing of extremely hard ore, and treat about 30 tons in 24 hours, the pieces being introduced in lumps about the size of the fist and ground down to pass through 0·02 to 0·04 inch (½ to 1 millimetre) mesh. The repairs consist in the renewal of the chilled-iron linings, which wear out in about 1½ years, and in the replacement of the cast-steel balls. These wear out at the rate of about 33 pounds (15 kilogrammes) of metal per 100 tons of ore.

Each separator consists of 2 rotating cylindrical portions, the separator proper and the discharging-drum. The separator consists of 4 circular electro-magnets, the ends of which are separated by brass rings, whilst they are coupled together at the shaft. The discharging-drum consists of 8 concentric rows of soft-iron pins, which are set in a wooden drum. The pulp is conveyed to the magnets, which attract the magnetic portion, whilst the non-magnetic portion flows away. The points of the discharging-drum receive temporarily induced magnetism as they approach the magnets, the result of which is that the particles of iron-ore adhering to the magnets are transferred to the former. Whenever these iron points recede from the magnets, they lose their induced magnetism, the grains of ore drop off, and are thus delivered to a separate

trough, by means of which they are carried away. The process is automatic, and one workman can look after several separators. A separator requires ¼ horse-power for driving and 8 amperes at 35 volts for the electro-magnets. By increasing or diminishing the quantity and tension of the current, the separators can be regulated with the utmost accuracy, so that they can also be employed for calcined red hæmatites and spathic iron-ores. With most other separators intermediate products are obtained, containing from 6 to 10 per cent. of iron. In this case there is no bye-product, and the tailings contain only from 1 to 1½ per cent. of magnetite. According to the contents of iron in the ore, these separators can treat from 25 to 50 tons of ore in 24 hours. The concentrate contains from 65 to 71 per cent. of iron, and it makes no difference whether the original ore contains 18 or 40 per cent. of iron.

A point of considerable importance to the process is the briquetting of the concentrates. Concentrates can only form a small proportion of a blast-furnace charge in the form of powder, as the furnace would readily become choked by their use in quantity. The greater portion must therefore be briquetted. This is done by compressing the wet powder into briquettes, and heating them in this form for a short period up to 700° or 800° Cent., or else by mixing them with from 3 to 5 per cent. of lime, and leaving the briquettes so formed for about two weeks, by which means excellent results have been obtained. A briquette-press produces in 24 hours more than 6 wagon-loads of briquettes, with a consumption of 6 horsepower. Such briquettes form an ore containing a high percentage of iron; they are porous and very easily reduced.

The available water-power, at the site selected for the works, was 125 to 150 horsepower, and including its utilization the costs of the erection of the works for the treatment annually of 120,000 to 150,000 tons were as follows:—

Plant.	Motive Power.	Florins.	£
2 Ore-breakers	12 horsepower	2,900	290
2 Bucket-hoists	4 ,,	1,600	160
8 Ball-mills	96 to 120 ,,	20,900	2,090
8 Magnetic separators	4 ,,	15,800	1,580
Dynamo and electric plant ..	4 ,,	1,600	160
Pump, 132 gallons (600 litres) per minute	4 ,,	650	65
Shafting and belting	—	5,200	520
Building	—	6,500	650
Erection and miscellaneous expenses	—	9,850	985
Totals ...	124 to 148 ,,	65,000	£6,500

If richer ore is to be treated, the proportion of separators must be increased. If the ore be excessively hard, only 75,000 tons can be treated per annum.

The working costs per annum are as follows:—

	Florins.	£
Maintenance of the crushing machinery	11,000	1,100
,, ,, hoists	1,300	130
,, ,, building	650	65
Wages, (high)	6,500	650
Administration and miscellaneous expenses ...	13,000	1,300
Totals	32,450	£3,245

—So that the cost for the treatment of 120,000 to 150,000 tons would be about 6½d. (26 kreutzer); or in the latter case, treating 75,000 tons, 11½d. (46 kreutzer) per ton. If no water-power is available, the cost for horsepower at £13 (130

florins) per horsepower per year must be added. The total costs thus amount to 8d. (32½ kreutzer) or 1s. 4d. (65 kreutzer) per ton of crude ore. At Pitkäranta, the costs of concentration, including the employment of steam-power from January to September, 1897, amounted to 11d. (1·16 francs) per ton of crude ore. H. L.

DENSE LIQUIDS USED FOR THE SEPARATION OF COAL AND SHALE.

Note sur l'Emploi des Liquides plus Lourds que l'Eau pour l'Analyse des Charbons et pour le Contrôle Rapide des Opérations de Lavage. By — MAURICE. *Comptes-Rendus mensuels des Réunions la Société de l'Industrie Minérale,* 1899, *pages* 144-165.

In the determination of the proportions of shale in small coal a rectangular metal box is used 3¼ inches square and 12 inches long, closed at one end and divided in the middle by a hinged door, which ordinarily is kept open by a spring, but can be closed by a chain from the outside. The lower portion of the box is filled with a solution of a proper density (one in which coal will float and shale will sink). The door is closed, a weighed sample of about 1 pound of small coal is placed in the upper portion above the door; and the box is filled with solution. The door is then lowered and the contents of the box are stirred, and after standing for a few seconds for the shale to settle, the door is shut. The separated coal is entirely contained in the upper portion and is collected upon a sieve with holes 0·08 to 0·12 inch in diameter, and the weight of the shale in the lower portion when the solution has been poured off gives a close approximation to the amount of incombustible matter.

The salts suitable for use are enumerated in the annexed table, giving the density of their saturated solutions at a temperature of 59° to 68° Fahr. (15° to 20° Cent.).

Suitable Salts.	Specific Gravity of Saturated Solution.	Suitable Salts.	Specific Gravity of Saturated Solution.	Suitable Salts.	Specific Gravity of Saturated Solution.
Calcium chloride	1·411	Calcium bromide	1·652	Magnesium iodide	1·910
Zinc sulphate ...	1·445	Barium bromide	1·712	Barium iodide ...	1·953
Potassium bromide	1·500	Potassium iodide	1·734	Calcium iodide ...	2·006
Cupric chloride ...	1·528	Zinc chloride ...	1·740	Zinc iodide ...	2·185
Sodium bromide	1·565	Sodium iodide ...	1·810	Zinc bromide ...	2·391
Ferric chloride ...	1·632	Cadmium chloride	1·890		

M. W. B.

RUSSIAN IRON-INDUSTRY.

L'Industrie Sidérurgique Russe, Etude Economique. By PAUL TRASENSTER. *Revue Universelle des Mines,* 1899, *vol. xlvi, pages* 151-213 *and* 273-312; *and vol. xlvii., pages* 33-68.

An idea of the enormous development of the iron-industry in Russia during the last few years is given by the fact that the pig-iron production, which was less than 500,000 tons in 1883, attained 1,000,000 tons in 1891 and exceeded 2,000,000 tons in 1898. The progress of the consumption has been still more rapid, as shown by the imports of iron-products, which have exceeded 500,000 tons for each of the last five years.

The remarkable progress of this industry in Southern Russia has been stimulated by foreign capital; but its future depends upon the extent of competition by other districts, which are also beginning to attract foreign capital. Central Russia, where there was an ancient charcoal-iron industry, has entered into the movement by resorting to Donetz coke; and the two Tula blast-furnaces have furnished an example that will soon be followed by others at Tambov, Orel, etc. The Ural does not refrain from the struggle, for large concerns have been started with Russian capital, while two French companies are endeavouring to rejuvenate the iron-industry by reserving the precious vegetable fuel for smelting the excellent local ores, and creating transformation-works on the Volga with naphtha as fuel.

A project for conveying the SouthernUral ores to the Donetz, which is due to the increased cost of Krivoï-Rog ore, appears rather premature with the present means of communication; but one of the large ore-deposits, that of Bakal, is provided with railway communication by the recent making of a branch from Bakal to the Berdiáuch station on the Samara-Zlatóust railway. The idea of bringing mineral fuel to the Ural ironworks comprises several variants, the most natural one being to use the Ural coals; but at present the latter have not yielded blast-furnace coke. Donetz coke has been tried at works in the Southern Ural; but carriage brings up the cost to about half as much again as that of charcoal. A proposition has also been made to use Siberian coke; but the nearest of the large Siberian coal-fields, that of Irtych, does not appear to yield a good coking coal, although this point is contested.

The iron-industry of Poland, handicapped by the absence of good ore and bituminous coal, is nevertheless making progress, thanks to cheap coal and labour. The rather artificial industry of St. Petersburg, that originated in the consumption of foreign pig-iron and fuel, is becoming nationalized, owing to very low carriage rates, that permit of its receiving pig-iron from the centre and south. The relative importance of the various districts is shown by the annexed table, which gives the production of pig and finished iron, and also steel, from the provisional statistics for 1898.

Districts.		Pig-iron.	Puddle-bars.	Steel Ingots.	Finished Iron and Steel.
		Tons.	Tons.	Tons.	Tons.
Southern		1,006,000	33,000	720,000	626,000
Central		180,000	73,000	160,000	178,000
Ural		714,000	357,000	190,000	385,000
Poland		263,000	75,000	245,000	252,000
St. Petersburg...		27,000	42,000	176,000	207,000
Totals ...	1898	2,190,000	580,000	1,491,000	1,648,000
	1897	1,336,000	572,000	1,200,000	1,371,000

Of the five iron-making districts in Russia, which are, in the order of their age, the centre, the Ural, Poland, St. Petersburg, and the South, the last-named and latest in point of development occupies the first rank as regards the importance of its production. This was already the case in 1897; and the preceding table shows that it produced last year 1,006,000 tons out of the

total of 2,190,000 tons, the total for 1897 having been 1,836,000 tons. Hitherto increase in the consumption has followed, or rather preceded, that of the production, as is shown by the large figure of the imports, those of last year representing 1,000,000 tons of pig-iron, one ton of finished iron being taken as representing 1¼ tons of pig-iron. Owing to the active demand, competition has not hitherto been too keen between the old and new districts; but such will not always be the case, and it is not without interest to inquire into the comparative economical conditions constituting the factors in the production of the various industrial centres.

The South possesses the fuel furnished by the large Donetz coal-field, which produces all the descriptions required by ironworks, and also the ore yielded by the Krivoï-Rog mines for the Bessemer process, and that of the Kerch deposit for the Thomas process. Both these classes of ore occur in large deposits that can be worked opencast; and they can be put out at very slight cost—about 2s. 6½d. per ton (2 kopecks per pud). The carriage from Krivoï-Rog to the Donetz costs about 6s. 11d. per ton (from 5 to 5½ kopecks per pud) to which must be added the royalty-rent and the mine-owners' profit; but this is at the outside 1s. 3¼d. per ton (1 kopeck per pud) for the old companies, while attaining three times and even more that rate in recent contracts. The sale price, less than 6s. 4d. per ton (5 kopecks per pud) before 1897, has now doubled; but new finds of ore to the south of Krivoï-Rog have reduced it to 10s. 9d. per ton (8½ kopecks per pud), and in future a mean of 9s. 6d. per ton (7½ kopecks per pud) on wagon, or about 15s. 8d. per ton (12½ to 13 kopecks) in the Donetz, may be reckoned upon. With coke at 16s. 6d. per ton (13 kopecks per pud) and efficient working of the furnaces, Bessemer pig-iron should cost £2 17s. 2d. per ton (45 kopecks per pud) at the Donetz furnaces. The Kerch ore does not cost much more than 5s. 1d. per ton (4 kopecks per pud) at the works on the coast, which have to pay about 4s. 5d. per ton (3 to 3½ kopecks per pud) for carriage of the coke, and which should, under these conditions, be able to turn out basic pig at £2 10s. 10d. per ton (40 kopecks per pud).

In the Central district are found phosphoriferous ores of moderate richness; but fuel is wanting, coke having to be brought from the Donetz at a cost of about 12s. per ton (9 to 10 kopecks per pud). Pig-iron, which must cost £3 3s. 6d. per ton (50 kopecks per pod), is not suitable for the Bessemer nor for the Thomas process, but only for foundry purposes or for puddling, and the Siemens-Martin basic process. The transformation is effected either with wood, as at Briansk, or with petroleum, as at Moscow and on the Volga, while costing appreciably more than in the Southern district; and under these conditions the development of a large iron-industry in the Centre appears problematical.

In the Ural, where there are large deposits of good iron-ore, but only vegetable fuel, charcoal-pig is produced at a comparatively low price—say about £3 6s. 8d. per ton (between 45 and 60 kopecks per pud); but on account of the high cost of fuel and financial charges, the transformation comes very dear, while the profit is comparatively slight.

In Poland, good ore and coking coal are wanting; and pig-iron is made for about £3 16s. 3d. per ton (60 kopecks per pud), or from 20 to 30 per cent. dearer than in the South. On the other hand, coal for the furnaces, and also wages are about 20 per cent. cheaper, while the labour is also more productive: but again the outlets are limited on account of the geographical situation.

The factitious industry of St. Petersburg appears to be the least valuable

under present circumstances, both ore and fuel being wanting; and the pig-iron is saddled with the cost of carriage, which varies from 15s. 3d. per ton (12 kopecks per pud) to £1 18s. 1d. per ton (30 kopecks per pud); and British coal pays an import duty of 1s. 10d. per ton (1½ kopecks per pud), costing about 17s. 1d. per ton (13 to 14 kopecks per pud) at the works, or twice as much as in the Donetz.

The above general remarks are, of course, subject to exceptions, because, independently of the natural conditions, account must be taken of the special circumstances of each concern, especially the mineral properties, the nature of the plant and manufacture, the technical management and the financial conditions. As regards the capacity for competition, the ratio of the profit to the value invoiced is the chief factor to be considered. In fact, if there be a fall of 10 per cent. in the sale price, this fall will leave a good margin for profit at works making 30 per cent. on the sum invoiced, while the conditions will be difficult for works only making 10 per cent. of that sum.

J. W. P.

AN ELECTRICALLY-DRIVEN COAL-STAMPING MACHINE FOR COKE-OVENS.

Ueber Kohlenstampfmaschinen. *By* H. W. *Glückauf*, 1899, *vol. xxxv.*, *page* 957.

The first attempts at compressing coal destined for the production of coke were undertaken in Upper Silesia. In these experiments, the operation was performed in the coke-oven itself, either by loading the charge during the coking process with heavy plates, or by compressing it with the aid of rollers; or finally, by using the coke-pusher itself as a compressor. As these various trials did not satisfy expectations, the attempt was made to pound the coal into a denser mass in a box made either of wood or iron. The coal is usually charged in layers, which are beaten by means of machinery.

Of the machines employed for the purpose, some compress the coal that is to be coked in a horizontal direction and by successive portions as they are charged; others, imitating the former operation of hand-pounding, stamp the coals vertically. Some of the coal-stamping machines have given very good results, namely, under normal circumstances a mass of coal measuring 40 inches in width, 32 inches in height and 26 feet long, is pounded and pushed into the coke-oven in an average time of 20 minutes.

In the Kuhn coal-stamping machine, the coal is admitted into the box by means of a hopper, furnished with slides which can be regulated, in five or six successive layers of a thickness of 10 to 12 inches. This coal-box is formed of iron plates corresponding to the shape of the oven. The sides are movable, so that after the charge has been pounded into a firm mass they can be removed, and the latter, together with the bottom plate of the box, is pushed into the oven. This plate runs on rollers, and is connected with a teethed rod, by means of which, through the intermediary of spur-gearing, it is moved by the machinery used for withdrawing the coke. The ram or stamper is fitted on a carriage which travels to and fro along the entire length of the coal-box.

The coal-stamping machine is worked by means of an electromotor which, by means of gearing, rotates a shaft and a crank. The crank is fitted with a connecting-rod, which moves a cross-head. A pawl fastened to the cross-head lifts the teethed rod of the ram until the lever of the pawl strikes a pin; the pawl is thereby released, and the ram falls by its own weight upon

the coal. By the motion of the crank the connecting-rod and the cross-head now begin to descend until at the bottom the lever strikes a second pin, and the pawl again engages the teethed rod, which by the revolving crank is lifted upwards; and thus the operation is repeated. A continuous and uniform blow is thus attained, for the ram from its last position is each time lifted a definite height and then falls, and as the thickness of the coal in the box increases the ram adapts itself automatically, so that whatever the thickness, a blow of a uniform strength is delivered. The coal-stamping machine is automatically moved in a horizontal direction along the box, whereby an uniform compression of the mass of coal in its whole length may be effected.

The coke produced from bituminous coal in virtue of the pounding acquires a denser and stronger structure, and is more suitable for metallurgical purposes; further, it is possible to add to the coal as much as 15 per cent. of non-bituminous coal without the coke showing any change in appearance or in the firmness of its mass. Moreover, a much dryer coal can be used, by which the quantity of gas necessary for heating the ovens is diminished. In consequence of the heavier charges, the daily increase in the production of coke per oven is about 10 per cent., without the time necessary for coking being correspondingly lengthened, and the waste at the top and bottom ends of the coke is less. M. W. B.

OTTO RECOVERY COKE-OVENS AT THE PREUSSEN I. COLLIERY.

Koksofen-Anlage mit Gewinnung von Nebenerzeugnissen der Zeche Preussen I. By H. *Glückauf*, 1899, *vol. xxxv., pages* 685-686.

A plant that will eventually consist of 160 ovens, fired underneath, 32·8 feet (10 metres) long, about 5·90 feet (1·8 metres) high, and 24·80 inches (63 centimetres) wide in the middle, now being erected at the Preussen I. colliery, Westphalia, is well calculated to show the great progress that has been made during the last five years in the construction and working of coke-ovens.

Before deciding on the construction of this plant, a stringent test of the coals was made at the Otto experimental coke-ovens, which was attended with very satisfactory results, showing a yield of 73·5 per cent. of coke together with 3·5 per cent. of tar and 1·35 per cent. of ammonium sulphate; and not one of the coke-ovens that has been in operation for 3 years has shown the slightest sign of deterioration through overheating. It is expected, when the whole plant is completed and in full work, that 240,000 tons of coke, 11,000 of tar and 4,200 tons of ammonium sulphate will be produced in a year, while such coke-ovens, fired underneath, generate 1·15 pounds of steam for every pound of coal coked. J. W. P.

PURIFYING BLAST-FURNACE GASES.

Procédés pour Epurer les Gaz des Hauts-fourneaux. ANON. *Echo des Mines et de la Métallurgie*, 1899, *page* 6,041.

An arrangement for intercepting a large portion of the dust carried along by the blast-furnace gases has been erected on a lately reconstructed furnace at the Chiers ironworks, Longwy, France, the principle consisting in a sharp change of direction given to the current. The apparatus consists of a cylindro-conical chimney, at the base of which is the gas off-take; and the gases pass into an annular space before reaching the main purifier, which is a rectangular chamber about 5 feet high, divided into three compartments by

partitions parallel with the short sides of the rectangle; and the bottom, containing water, assumes the form of an inverted truncated cone, fitted with a sliding-door for removing the intercepted dust. The gases enter the first compartment by a vertical pipe fitted with safety-valves, strike against the surface of the water and rise, to descend again in the same manner for the other two compartments. After these changes of directions, owing to which the greater portion of the dust has been thrown down into the water, part of the gas is sent to the boilers and the rest to the hot-air stoves, which only require cleaning every six months. J. W. P.

RAISING THE TEMPERATURE OF BLAST-FURNACES BY INJECTING HEAVY OILS.

Surélévation de la Température des Hauts-fourneaux par Insufflation d'Huiles lourdes. By F. LAUR. *Echo des Mines et de la Métallurgie,* 1899, *page* 6,041.

This method of superheating the blast consists in interposing between the hot-air stoves and the tuyeres an injector of heavy oils, which pass into the furnace, increasing the temperature and the yield, while greatly facilitating reduction of the ore. It has been tried with satisfactory results. Thanks to this arrangement, only smoothed-faced pig-iron is produced, while the carbon- and silicon-contents are considerably increased. J. W. P.

AN ELECTRICALLY-DRIVEN STEEL MILL.

An Electric Steel Mill. ANON. *Mines and Minerals [Scranton, Pa.],* 1899, *vol. xx., pages* 137-138, *with* 2 *illustrations.*

At Ensley, 8 miles from Birmingham, Alabama, a new plant has been erected by the Alabama Steel and Ship-building Company. The capacity of the plant is 1,000 tons of steel daily, the product of ten open-hearth furnaces. There is also a 44 inches blooming-mill, and a 27 inches finishing-mill. The plant presents the most modern electric equipment in America and probably in the world. In the central power-house there are two units of 225 kilowatts direct-current generators, to which a third unit is now being added. The generators supply current to the numerous electric motors used throughout the works, and provide for lighting the mills. The furnace-charging machines are driven by electric motors; the molten steel is handled by electric cranes; the moulds, after being filled with molten steel, are propelled by an electric locomotive, and the ingots are drawn through the re-heating furnaces by electrically-driven gearing. In the blooming-mill, the feed-tables, the travelling tables, and the housing-screws are operated by electric motors. The run-out tables to the shears, etc., are driven by electric motors. From the point of passing through the shears, both billet and scrap are handled by electric conveyors, and an electric-trolley locomotive shifts the cars under the conveyor. All the departments of the mill are fitted with overhead travelling-cranes operated electrically, and, in fact, from the arrival of the crude-ore at the mills until its delivery as finished steel electricity takes an active part in every stage of manufacture. In the operation of the gas-producers and boiler-plants, electric motors turn the grates, feed the coal into the grates, operate the blowers, and carry the ashes from the boiler-plant

out of the building. In the whole of this extensive plant, there are but five steam-engines, two of which are used to generate electricity, the latter agent performing the duties which would have required fifty steam-engines.

X. Y. Z.

THE COPPER INDUSTRY OF CHILE.

La Industria del Cobre en el Chile. *By* J. VELÁSQUEZ JIMÉNEZ. *Anales de la Sociedad Cientifica Argentina,* 1899, *vol. xlviii., pages* 209-238, *with four figures in the text.*

The author sketches the recent history of the copper-industry in Chile, and shows from the statistics of exports that it reached its culminating point in the decade 1876 to 1885, since which year the exports have continuously declined. He then describes the famous "corner" in copper of 1887-1889, and points out that the Chilian mine-owners suffered far more from that disastrous speculation than the metallurgists. There was every incitement to work the mines in the most wasteful manner, leaving great hollows and labyrinths of irregular drifts, which now constitute a serious drawback to further mining-operations. In their feverish haste to get every available scrap of copper out of the mines, the lessees soon drove through to the barren zones: at depths of 1,000 and 1,500 feet the high mineralization of the sulphides ceases, the main leader generally branching out into thin veins of small industrial value. It is held to be an axiom that at a particular level the workable leaders die out, and the greater number of the Chilian mines have now reached this zone of impoverishment. Hence the continuous decrease in the output, with the result that out of 18 smelting-works which were 5 years ago in full activity only 8 now remain in Chile. The author agrees, however, with Mr. San Roman, in believing that beyond the zone of impoverishment rich cupriferous leaders will be found to recur. This view is remarkably borne out by the case of the Carrizal Alto district, where leaders assaying to 11 and 12 per cent. of metal have been struck, despite the practically universal opinion of the experts, at a depth of 1,300 feet or more. At Copiapó, a British company is working very successfully the Dulcinea mine at a depth exceeding 2,300 feet: here the pyritiferous leaders assay on an average to 20 per cent. of metal. It seems probable that fresh exploration-work, if backed by a sufficient amount of capital, would prove equally successful in many other Chilian mines.

The remaining and larger portion of the memoir (22 pages) is devoted in the first place to a description of the smelting-works of Tierra Amarilla, near Copiapó, where two methods of treatment are in vogue: (1) the English method, whereby the whole series of operations is conducted in reverberatory furnaces, and (2) the Continental method, embracing the use of blast-furnaces with water-jackets. Then attention is invited to the Lota works, owned by a company whose fleet of steamers and sailing-vessels carries lignite (got in their own mines) to the northern ports of Chile, bringing back copper-ore as ballast. It may be noted, by the way, that this company's monthly output of Lota lignite averages 20,000 tons, of which about 50 per cent. crumbles into a sort of charcoal-breeze. Instead of wasting this breeze, the company have started various industries in which they make use of it themselves. Thus, utilizing the quartzitic sands of the locality, they have developed potteries and glassworks, and they make firebricks, of which they consume 400,000 *per annum,* selling the surplus to other Chilian smelting-works. Feeding their

own smelting-works with the return cargoes of their fleet, this company treat daily about 130 tons of ore, two-thirds of which are oxides, the remaining third being sulphides. Reverberatory furnaces are used for roasting the ore and forming the matte; Manhes converters (introduced in 1890), for transforming the matte into black copper; and blast-furnaces for treating the scoria from the converters, the black copper being refined in small reverberatory furnaces. L. L. B.

ROASTING COPPER-ORE AT KESWICK, CALIFORNIA.

By T. Neilson. *Engineering and Mining Journal* [*New York*], 1899, *vol. lxviii.*, *pages* 457-458.

As roasting admits of many variations, it was the practice of the Mountain Copper Company, at Keswick, to experiment and find out the cheapest and most satisfactory methods. After a great many trials, it was found that the results of stall-roasting did not compare favourably, either in quality or cheapness, with heap-roasting, and the heap-roasting was therefore extended and practically all coarse ore is now roasted in that way. The advantages claimed for stall-roasting were more than counterbalanced by matting, more expensive discharging, constant repairs, and heavy initial cost of construction. For good practice, a heap 20 feet wide, 8 feet high, and from 500 to 1,500 feet long (according to the nature of the ground) was found to be the most suitable size. But unless some system of electric traction is used, it is advised that heaps should not be more than 500 feet long where plain cars are in use. Experiments were also made with the object of hastening the calcination of the ore. About 10 feet apart, holes were drilled under the heap, or earthenware tiles were laid there before the heap was built. These holes were blasted with powder when the heap had burned for 2 or 3 months, but the results were not satisfactory. A displacement of the ore all over the ground occurred, or else slight fissures were made. In one case, calcination stopped from excess of air, and in the other matting resulted. Blasting is beneficial when the heap is almost dying out, and then serves chiefly to cool the ore and make it more easily handled by the shovel. For several months past, the company has employed a 20 cubic feet steam-shovel for the purpose of discharging the heaps, and the result has been to lessen costs. The author also introduced a fresh method of heap-building. In this case, the ore was screened at the mines, and by building on a long stretch of ground (1,500 feet) a temporary trestle, strong enough to bear the weight of a loaded train of 100 tons of ore, the ore could be brought to the heap without any intermediate processes, saving the cost of bunkers, grizzlies, tramcars, and small trestles. When the heap was completed, the timbers were pulled out and could be used over again for the same purpose. The following estimates of costs will show the saving by the improved systems of handling:—

	Indirect Loading.			Direct Loading.	
	Cents.	Pence.		Cents.	Pence.
Labour...	15·00	7·50	...	6·25	3·12
Cordwood	2·50	1·25	...	2·50	1·25
Poles left in	0·20	0·10	...	—	—
Proportionate cost of lumber & rails	0·16	0·08	...	0·54	0·27
Stores	0·04	0·02	...	0·02	0·01
Totals	17·90	8·95	...	9·31	4·65

	Discharging (Manual). Cents.	Pence.	Steam-shovel. Cents.	Pence.
Labour...	20·50	10·25	4·50	2·25
Repairs	—	—	0·10	0·05
Stores	2·50	1·25	0·12	0·06
Interest	—	—	0·20	0·10
Totals	23·00	11·50	4·92	2·46
Total	40·90	20·45	14·23	7·11

These statistics show a saving in favour of the new system of 1s. 1·34d. (26·67 cents.), which on 500 tons per day (and from 500 to 800 tons are handled from the mine daily) is equal to a saving of nearly £10,000 (50,000 dollars) per annum. Heap-roasting is suited only to comparatively dry climates and districts where the fumes of sulphurous acid, etc., will not destroy vegetation. For like reasons, it would not be advisable to bring the heaps within close proximity of towns. Heap-roasting is a primitive but cheap process, although it seems wasteful to lose such a valuable ingredient as the sulphur; still, as the market for sulphur and sulphuric acid is far away from Keswick, the article would be a drug on the market. X. Y. Z.

INFLUENCE OF PEATY WATER ON THE AMALGAMATION OF GOLD-ORES

Ueber den Einfluss von Moorwasser auf die Amalgamation von Golderzen. By W. Witter. *Berg- und Huettenmännische Zeitung*, 1899, *vol. lviii., pages* 349-354.

The author examined in the summer of 1897 a gold-mill in the province of Småland, in Sweden. The ores which were there worked were pyrites, carrying on the average 18 pennyweights (30 grammes) per ton of free gold and some silver. The water used in the stamp-mill was taken from the river Eman, which passes close to the works, and the water of which is chiefly derived from peat-moors. In the autumn, winter and spring, and also in summers with a heavy rainfall, the amalgamation of the ores presented no difficulty, but when the river carried but little water, and when warm, dry weather ruled, the amalgamated plates became covered with a green slime, which almost prevented the mercury from taking up any gold. Although all possible methods were resorted to, such as the addition of milk of lime to the water, or the filtration of the latter through a filter of burnt lime, this effect of the water still remained. As soon as the green slime was rubbed off the plates, it rapidly formed again; and it finally became necessary to stop amalgamation during the dry season.

The author examined both the river-water and also the green deposit, and he has proved that it was organic matter which caused the difficulty. Upon adding milk of lime to the water which contained the organic substance in a concentrated form (20 litres were evaporated down to 500 cubic centimetres), a considerable deposit of a greenish colour was produced. When this deposit was heated, it burnt and left but little residue; on burning the green slime, a cupriferous ash remained.

The cause of this phenomenon must, therefore, be sought in the humus and the humic acids which the water had derived from the peat. According to Prof. Fischer, humic acids form insoluble compounds with metals. It is

therefore highly probable that the water containing humic acid would attack the amalgamated copper-plates, in spite of their being silvered, thus producing the insoluble green precipitate which covered the surface of the mercury.

Experiments tried in the Hamburg laboratory in order to further clear up this interesting point led to no result. It was noticeable that pure, bright sheet-copper, which was allowed to stand for 6 months in the concentrated water, showed no signs of the formation of the green deposit. H. L.

CHLORINATION OF GOLD-ORES AT MOUNT MORGAN.

By Edgar Hall. *Engineering and Mining Journal* [*New York*], 1899, *vol. lxviii.*, *page* 426.

The famous gold-mine at Mount Morgan, Queensland, probably possesses the largest chlorination-mill in the world. Until a few years ago, barrel-chlorination was the method chiefly adopted with practically no improvements. But chlorination, as conducted at Mount Morgan to-day almost deserves the name of a new process. The gold is still chlorinated and extracted from the chloride-solutions by means of charcoal, but the methods are completely altered. Direct leaching of the ore in open vats by a solution of chlorine in water has rendered possible the employment of much larger plant. The roasting-plant has also been remodelled, very large revolving-cylinders, with continuous discharge, being used for the oxidized ore, and the Richard furnace for the pyritic ore. This furnace is very economical in fuel, has a large output, and furnishes a thoroughly oxidized product. The ore moves automatically over inclined planes in such a way that the quantity of ore per square foot lying on the hearth increases as the end of the roast is approached, while the speed of travel decreases. The movement is assisted towards the end by jets of air, which also serve to supply oxygen. This is an expensive furnace, but it secures the low initial heat and final high temperature required by theory in a very perfect manner, and it makes hardly any flue-dust. The gases issuing from the furnace are exceptionally rich in sulphurous acid and low in oxygen, thus pointing to a high chemical efficiency. Various mechanical roasters were tried without success before the Richard furnace was evolved.

The West Works, for the treatment of mundic ores solely, embodies the latest Mount Morgan practice. The ore is dry crushed in Krupp ball-mills, then roasted in Richard furnaces, cooled by an ingenious device, and conveyed automatically to large bins, from which it is trucked to the vats. The vats are very large oblong tanks made of cement-concrete, about 4 feet deep, and with a filter-bed of sand and gravel on the bottom. The vats are perfectly open on the top, and the leaching of the ore is conducted in exactly the same manner as ordinary cyanide or hyposulphite-lixiviation. The chloride-solution is passed through charcoal-filters for precipitation of the gold. The filters are made very large, and lined with cement. The chlorine is generated in stills, in the ordinary way, from manganese, salt and sulphuric acid, and absorbed in water contained in large cement-lined covered tanks. Portland cement is used wherever chlorine-bearing liquids are dealt with, not even omitting the chlorine-stills.

This open-vat lixiviation of gold-ores by chlorine-water has reduced costs enormously. It simplifies the whole process, renders it applicable on any scale that may be desired, and for gold-ores which require roasting it is much

cheaper than cyaniding. It is also applicable to ores carrying a small amount of copper, where cyanide would fail altogether. The new practice has rendered profitable the enormous quantities of low-grade ores existing in the mine. X. Y. Z.

MAX NETTO PROCESS OF TREATING GOLD AND SILVER ORES.

Note sur le Procédé Max Netto pour le Traitement des Minerais d'Or et d'Argent. By L. LEGRAND. *Revue Universelle des Mines*, 1899, vol. xlv., pages 125-136.

Favourable results have been obtained by the author working with this process at the Horcajo silver-lead mines, Spain, and favourable reports have also been received from Hiendelaencia. The method of treating the ores of the precious metals varies according to whether they are purely argentiferous, or auriferous, or mixtures of both.

Argentiferous ores are crushed fine and treated with potassium-cyanide solution, the dissolved silver being drawn off and precipitated by hydrochloric acid. The precipitate only requires filtering in a press to be ready for market; and the cyanide is recovered by treating the waste liquor with caustic soda or milk of lime.

Auriferous ores are also finely crushed, and extracted by means of potassium cyanide; but the gold solution is treated differently, being first rendered slightly acid with hydrochloric acid and then electrolysed in a Netto-Roscher apparatus. This consists of a number of superimposed wooden frames, enclosing perforated sheets of lead, about 0·02 inch thick, and spaced 1 inch apart, the frames being held tightly together by clamps engaging on the wooden cover and base. A current of 0·2 volt and 3·5 ampères per square metre (10·76 square feet) of electrode induces the deposition of the gold on the cathode, along with a portion of lead dissolved from the anode. The gold is easily recovered from this spongy mass by cupellation, whilst the cyanide is won back from the electrolyte as before.

Mixed ores, such as require chlorination-roasting, are subjected to this treatment, and, as the soluble sulphates then formed preclude the employment of electrolysis, the solution is treated with hydrochloric acid to precipitate the silver—a small proportion of the gold being also carried down. The liquid is decanted, slightly acidified, and treated with a mixture of zinc-dust and spongy lead, the former accelerating the deposition of the gold upon the lead. A larger amount of cyanide than usual is consumed in this process, the presence of zinc preventing complete recovery.

If the ore does not require chlorination, the same treatment is adopted as for argentiferous ores, the gold being in part thrown down with the silver, and the remainder recovered by the electrolytic treatment—either direct, when the gold is in relatively large proportion, or after collecting a sufficient quantity of the residual solution.

The argentiferous slimes treated at Horcajo, contain 14 per cent. of lead and 38½ ounces troy (1,200 grammes) of silver to the ton. It has been found advantageous to subject them to chlorination-roasting with 5 per cent. of salt and 2 per cent. of pyrites, as this increases the amount of recoverable silver and also facilitates lixiviation. When chlorinated, the mineral is treated with a 0·3 per cent. solution of potassium cyanide. In practice, double the theoretical quantity of cyanide is required to entirely dissolve the silver. After 6 days' treatment, the unextracted silver is reduced to 5¾ ounces troy (180 grammes) per ton, this being probably combined with galena.

Precipitation is effected in large tanks, ½ gallon (2¼ litres) of 33 per cent. hydrochloric acid being required per 2·2 pounds (1 kilogramme) of silver; the use of any other acid involves a loss of cyanide reagent, the silver being in such cases thrown down as silver cyanide. When pressed and dried, the cakes of silver chloride contain on an average 56 per cent. of silver. The total working expenses come to less than 20s. (24·90 pesetas) per ton.

When the mineral contains a large proportion of lead, the lead sulphate formed from the galena during roasting remains in the residue from the cyanide process and can be concentrated and recovered, together with a portion of the unextracted silver. C. S.

PROPERTIES OF ALUMINIUM.

Sur les Propriétés de l'Aluminium. By A. DITTE. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, 1898, *vol. cxxvii., pages* 919-924.

Tho resistance offered by aluminium to chemical influences is more apparent than real, and is in fact due to the protection afforded by the rapid formation of a thin superficial film (of *e.g.* hydrogen, nitrogen dioxide, or alumina), according to the nature of the reagent in which the metal is immersed, and which is therefore prevented from coming into close contact with it. If this film, however, be removed continuously as soon as formed, the attack of the metal will proceed until complete solution has been effected. A solution of sodium chloride, or similar salt, will appreciably dissolve the metal; aluminium chloride being at first formed, but this is subsequently converted into the oxide by double decomposition, the entire reaction liberating (157·3 + 287 =) 444·3 calories. The second part of the reaction is suppressed when free acid is present in the salt-solution, aluminium chloride being then produced and hydrogen liberated continuously, until all the metal is dissolved, or until the free acid is exhausted. Acid salts have a similar effect, the metal being gradually attacked, for instance, by a mixture of sodium chloride and potassium bi-tartrate or bi-oxalate; other halogen compounds—bromides or iodides—may also replace chlorides in the reaction, which in such cases still remains exothermic.

Under the influence of alkali carbonates, such as are generally employed for cleaning utensils, aluminium is rapidly attacked, sodium aluminate being formed and hydrogen liberated, whilst the carbon dioxide set free goes to form bi-carbonate with the alkali mono-carbonate. The reaction only ceases when the whole of the latter has been converted into bi-carbonate. Pure aluminium is also attacked by ammonia, until the surface of the metal has become coated with a crystalline film of aluminium hydroxide. C. S.

ELECTROLYTIC PRODUCTION OF CRYSTALLINE TUNGSTEN.

Sur la Production par Électrolyse du Tungstène Crystallisé. By L. A. HALLOPEAU. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, 1898, *vol. cxxvii., pages* 755-756.

The author finds that lithium paratungstate is reducible to tungsto-lithium tungstate by tin, and that a further reduction to crystallized tungsten dioxide can be effected by means of hydrogen at a red heat, this oxide being converted into the metallic state when greater heat is employed. When sodium or potassium tungstate is electrolysed, tungsto-alkali tungstates are

formed; but the results are different when the lithium compounds are subjected to the same treatment. Thus, on fuzing lithium paratungstate in a porcelain crucible, raising the temperature to about 1,000° Cent., and subjecting it to a 15 volts 3 ampères current for 3 hours, with platinum electrodes, then washing the mass successively with boiling water, concentrated hydrochloric acid, a boiling 20 per cent. solution of lithia, and cold water, a decidedly crystalline residue was obtained, which proved, on analysis, to consist of metallic tungsten, containing up to 6 per cent. of platinum (derived from the electrodes). The crystals are opaque, have a fine metallic lustre, and are prismatic in form, most commonly acicular and probably due to agglomerations of octahedra, as in the parallel forms exhibited by silicon.

Iron electrodes proved unsuitable, owing to the rapidity with which they were corroded by the fused salt. The author proposes to repeat his investigations, with platin-iridium electrodes. C. S.

UTILIZATION OF COAL-DUST AND SLIMES AS FUEL.

Ueber Verwerthung von Kohlenschlamm und Kohlenstaub. ANON. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen, vol. xlvii., pages* 127-129.

Fine coal-dust, containing from 26 to 28 per cent. of ash and 7½ per cent. of water, and the slimes deposited from the settling-ponds of coal-washeries, containing 30 per cent. of ash and 19 per cent. of water, are burnt under Lancashire boilers by means of the Bechem and Post system, consisting of an air-blast at a pressure of not less than 4 atmospheres, the velocity of the current being sufficient to set the bed of fuel in motion and burn the finely-divided carbonaceous matter whilst in suspension, giving a large volume of flame, whilst the fire-bars are scarcely red-hot. Owing to the large amount of incombustible matter, the labour in stoking and clearing the fires is about double that required with ordinary coal. Reckoning the dust and slime-coal at 2s. per ton, the cost of evaporating a ton of water is about 1s., whilst with coal at 8s. 6d. per ton, the cost of evaporating a ton of water is 1s. 7d., or a saving of about 30 per cent. With small coal, costing 6s. 5d. a ton, the saving was 26 per cent. M. W. B.

COAL-DUST FUEL FOR FIRING BOILERS AND HEATING FURNACES.

De l' Emploi du Charbon Pulvérisé dans les Foyers des Chaudières et des Fours métallurgiques. By A. HALLEUX. *Revue Universelle des Mines,* 1899, *vol. xlvi., pages* 21-34.

The importance of using coal-dust in connection with the utilization of small or inferior fuel justifies the numerous investigations to which this subject has given rise; and the present state of the question may be summed up as follows:—

The Schwartzkopff method has given sufficient practical results to attract the attention of manufacturers; and the realization of this very rational idea leads especially to a better utilization of the heat furnished by a combustible, while permitting of only the calorific value of a coal being taken into consideration independently of its physical state; and on the other hand, in connexion with the laying down of boilers and furnaces in large towns, the combustion, almost perfect, is effected without the production of smoke.

J. W. P.

EVAPORATIVE EFFICIENCY OF OIL-FUEL.

Crude Petroleum and its products as Fuel. By H. TWEDDLE. *Engineering and Mining Journal [New York]*, 1899, *vol. lxviii., pages* 459-460, 488-490, *and* 517-520, *with* 18 *illustrations.*

The author has for many years used crude oil in stationary boilers and furnaces without accident, but would consider the general use of such fuel in locomotives and steamers most dangerous. For such purposes, no petroleum with a fire-test of less than 200° Fahr. should be used. With a fire-test of 250° Fahr., it is a safer fuel than coal. The simplest and best way of burning liquid fuel is by injecting it in the form of spray by means of a steam-jet into the furnace and allowing the right amount of air to mix with it. Numberless different injectors or burners have been devised for this purpose, but the author contends that the proper place to improve is the combustion-chamber. In order to obtain the greatest efficiency, the oil should be burned in a confined combustion-chamber at the highest possible temperature. It is most necessary that the combustion-chamber be of a refractory non-conducting substance, which soon becomes heated to incandescence, and that all gases, together with the incoming air, must pass through this focus of heat. In the case of locomotives or steamers much better results are obtained when the oil is injected with a steam-jet, but air-injected oil is more suitable for forges and furnaces for heating iron or other metallurgical operations. The chemical combinations that occur in this high-temperature furnace are not very well defined. Theoretically, the carbon becomes oxidized into carbon dioxide and the hydrogen to water, but on several occasions when the author was engaged in experimenting on the evaporative efficiency of fuels, the evaporative efficiency actually obtained was greater than that theoretically possible. In these experiments, the fuels were analysed, weighed and their theoretical efficiencies calculated; the amount of steam evaporated was also carefully freed of any water which might have been carried over mechanically; it was condensed and weighed; the amount of air entering the furnace was measured, and as far as possible, all factors of error were eliminated. Under such conditions accurate results might have been expected, but on many occasions, especially when using steam-injected oil and working under heavy forced draught, the evaporative efficiency obtained was greater than the theoretical efficiency. Moreover, there seemed to be no control applicable to these results—sometimes they would happen and sometimes not. But when they did happen, the author always noticed that for some reason the focus of heat was more intensely incandescent than usual, and that the combustion-chamber was almost free from flame. It was, in fact, a case of flameless combustion, and the author was led to believe that at these extremely high temperatures combinations might occur with which we are as yet unacquainted. But, although the author suggests a theoretical explanation of these results, his chief object is to draw attention to the fact that the higher the temperature obtained in the furnace the greater is the economy in the use of liquid fuel. X. Y. Z.

COAL-SUPPLY TO A CENTRAL ELECTRIC STATION.

Une Usine Parisienne. By ROBERT PITAVAL. *Echo des Mines et de la Métallurgie*, 1899, *vol. xxvi., pages* 5,614-5,615.

The coal-boxes at the generating station on the Quai de Jemappes, Paris, of the Société Parisienne de l'Air Comprimé, are situated on the fourth floor;

and the coal is now taken out of the barges and delivered into the boxes by a combined conveyer and elevator of recent design, by which a 300 tons barge is discharged automatically in a day. An electric crane on the quay transfers the coal from the lighter to a hopper; and it is then taken by a conveyer, 26 feet (8 metres) long, which traverses the quay by an underground passage, the coal being brought to a tipping-hopper, where it is weighed automatically. It is then taken up by an elevator, 131 feet (40 metres) high, to the upper hopper, whence horizontal conveyers deliver it into bunkers over the various boilers. The plant works well, stopping immediately on the least irregularity occurring; but, as the fuel consists almost entirely of slack, the dust quickly chokes the rollers, notwithstanding the fact that every part is cased in. On the third story are 28 Delaunay-Belleville boilers (with space for 12 more), laid on a strong floor covered with sheet-lead. The feed-pumps draw from the decantation- and purifying-tanks on the second floor, the salts in solution being precipitated by lime and soda. After filtering through wood-fibre, the water only possesses 5 degrees of hardness; and it is then heated in economizers. On the first story, are 7 dynamos, each of 700,000 watts, driven by 1,200 horsepower compound Corliss engines. J. W. P.

COSTS OF STEAM AND WATER-POWER.

The Comparative Cost of Steam and Water-power. By WILLIAM O. WEBBER. *Engineering Magazine*, 1898, *vol. xv.*, *pages* 922-927.

The cost of working a 1,000 horsepower steam plant is as follows:—

	Per Horsepower per annum. s.	d.
Interest on capital, depreciation, repairs, etc.	27	3
Coal (1·4 pounds per indicated horsepower at 16s. 0½d. per ton)	30	10½
Wages (2 engineers and 2 stokers)	12	10
Oil, waste, etc.	3	4

The lowest cost known to the author is £2 8s. 6d. per horsepower per annum, with coal at 7s. 4d. per ton. This plant consists of a vertical compound condensing engine, with an average load of 950 horsepower, working at a steam-pressure of 155 pounds per square inch, with Heine water-tube boilers. An exhaust-steam heater, and a Green economizer are used.

The cost of water-power plant, comprising 3 wheels, producing a maximum of 510 horsepower and an average of 315 horsepower, is £1 3s. 2d. per horsepower per annum. M. W. B.

CENTRAL CONDENSATION PLANT AT THE RECKLINGHAUSEN COLLIERY.

Die Central-Kondensation des Schachtes Recklinghausen II. und ihre Betriebsergebnisse. By W. M. *Glückauf*, 1899, *vol. xxxv.*, *pages* 485-488, *with drawings.*

For better utilizing the steam-power available at No. II. pit of the Recklinghausen colliery, a central condensation-plant has been in operation since August, 1898; and seven months' uninterrupted working permit of determining the amount of saving effected, and also the economy afforded by central condensation in general. The plant belongs to the type of open

surface-condensers, which are distinguished by the circumstance that the series of pipes that act as condensers are laid in an open basin, in which the water for cooling laves each series separately, on the counter-current principle, in contradistinction to the so-called closed condensers, in which the exhaust-steam surrounds the series of water-tubes laid in a closed cyclindrical chamber; and also in contradistinction to the spray-condensers, in which the series of pipes are cooled by trickling water.

The exhaust-steam of the engines put in connexion with the condensation-plant collects in the common pipe that leads it directly to the condenser, which consists of 8 groups of pipes placed side by side, and each group comprizing 110 brass pipes, 16 feet (5 metres) long and 1¾ inches (44 millimetres) in diameter, with a thickness of 0·079 inch (2 millimetres), and having a collective cooling-surface of 8,073 square feet (750 square metres). The condensate, a mixture of air and water, flows by gravity into the deepest receiver, or air-separator, where the separated air is taken off by a pipe connected with the upper portion, while what is called the condensate-pump draws off the water by a pipe connected with the bottom of the receiver, and forces it into a large chamber situated over the filter for purifying the water. In this chamber, the oil is separated from the water, which is then completely purified in a gravel-filter, of which there are two, so that one can be cleaned without interruption of the working. While any oil still remaining is retained by the gravel, the purified water flows by a pipe, fitted with a strainer in the floor of the filter, into a collecting-chamber, whence it is admitted by a sliding-valve into the clean-water reservoir to serve for feeding the boilers.

The above arrangement, however, did not entirely separate the oil, so that small coke was substituted for the gravel, when the effluent was found to be far clearer, while the coke could still be employed for fuel, whereas the gravel simply went to increase the spoil-tip; but the water in the first filter must be sufficiently cooled down for the oil to be separated with sufficient rapidity. In order to be able to use over again the water which laves the brass pipes, it must also be cooled down; and it is accordingly drawn by a pump from the exit-portion of the cooling-basin and forced to the self-ventilating graduation-building some distance off, which is divided into three compartments, each 4·59 feet (1·4 metres) wide, 17·71 feet (5·4 metres) high and 197 feet (60 metres) long. Directly the plant was brought into operation, however, a great difficulty presented itself. Owing to constant evaporation, the salt-content of the mine-water continually increased, because a portion of the water in dropping from the graduation-house is carried away by the wind, exerting a destructive action on vegetation, which it was attempted to remedy by the use of louvres. The cooled water flows by gravity to the condensation-reservoir before again beginning its cycle.

The plant is destined to deal with 21 tons of steam at a pressure of 81 pounds per square inch (5 to 6 atmospheres) per hour, comprizing that of the winding and pumping-engines, the air-compressor, the fan and electric-light engines, a few engines for driving machine-tools, and lately the engine for driving the brick-making machines. The result has been a reduction in the quantity of coal used for firing the boilers from 1,983 to 1,681·3 tons or 301·7 tons per month, corresponding with a reduction from 8·13 to 5·68, or of 2·45 per cent. of the coal drawn. The saving is really greater than that shown by the figures, because the output increased, about 1,020 tons having been raised daily on an average before the plant came into operation, and 1,159½ tons afterwards, involving a larger consumption of steam. The saving of feed-water amounted to 79,200 gallons (360 cubic metres) for each working day,

effecting an economy of £583 4s. (11,664 marks) per annum, and thus bringing up to £2,473 4s. (49,464 marks) the total yearly saving in fuel and feed-water together.

J. W. P.

CONVEYANCE OF COMPRESSED AIR.

By PROF. ROBERT PEEL. *Mines and Minerals* [*Scranton, Pa.*], 1899, *vol. xx.*, *pages* 135-136.

In a series of papers dealing with the subject of compressed air, the writer remarks that whilst for short distances the loss of pressure during transmission may be considered as taking place according to the recognized laws of fluids, the application of these laws becomes somewhat complex for long distances. The formulæ commonly used are constructed on the hypothesis that the loss of head is strictly proportional to the length of the pipe, so that if a certain head be required to maintain the flow of a given quantity of air in a pipe 1,000 feet long, twice this head would suffice for a pipe 2,000 feet long. But this rule fails to take into account the increase of volume due to reduction of pressure or loss of head. When the air has passed through the first 1,000 feet, head has been lost and the volume thereby increased, and a greater head will be required to pass the greater volume through the second 1,000 feet. The author, however, points out that by far the greater bulk of pressure is lost by leakage and by pipe-bends of too small a radius. With due attention to these points, transmission-losses may be reduced to a very small amount. At the Hoosac tunnel, in transmitting 875 cubic feet of free air per minute, at an initial pressure of 60 pounds, through an 8 inches pipe, 7,150 feet long, the average loss of pressure, including leakage, was only 2 pounds. In driving the Jeddo mining-tunnel, at Ebervale, Pa., two 3¼ inches drills were used in each heading with a 6 inches main, the maximum transmission-distance being 10,800 feet. This pipe is so large in proportion to the volume of air (230 cubic feet of free air per minute) required for the drills that the loss was reduced to 0·002 pound, and the gauges at each end of the main were found to record practically the same pressure.

Each bend or elbow in a pipe-line has a serious retarding effect. For the same diameter of pipe the resistance caused by a bend increases as the radius of the curve diminishes, but the exact relation is not accurately known. In the absence of sufficient experimental data, the annexed table may be used:—

RESISTANCE OF ELBOWS OF DIFFERENT RADII.

Radius of elbow in terms of diameter of pipe	5	3	2	1½	1¼	1	¾	½
Equivalent length of straight pipe in terms of its diameter which would offer a resistance equal to the above-named elbow	7·85	8·24	9·03	10·36	12·72	17·51	35·09	121·20

X. Y. Z.

ELECTRIC PLANT AT MONT-DORE.

Nouvelle Installation Hydroélectrique du Mont-Dore. *By* A. LAVEZZARI. *Mémoires de la Société des Ingénieurs Civils de France*, 1898, *vol. iii.*, *pages* 72-86.

This electric plant is driven by hydraulic power from the Lake of Guéry, which is situated about 6 miles from the town. A masonry-dam built across

the end of the lake raised the level of the water 16 feet. A steel-pipe, 23½ inches in diameter, 0·16 inch thick, and 2,820 long, with a head of 130 feet, yields about 250 horsepower. At the works the water is led to three turbines, coupled direct to three dynamos, furnishing a continuous current of 550 volts, which is carried by a double cable to Mont-Dore, where the current is reduced to 115 volts. The total cost was £6,250. M. W. B.

UTILIZATION OF BLAST-FURNACE GAS.

Etat actuel de la Question des Moteurs à Gaz de Haut-fourneau. By H. Savage. *Revue Universelle des Mines*, 1899, *vol. xlvii pages* 1-16.

Without detracting from the merit of other pioneers in the utilization of blast-furnace gas, it would be unjust not to render homage to the foresight and initiative of Mr. Armand Bailly, who, so early as May, 1885, proposed to utilize the power of blast-furnace gases. The results acquired under his auspices could not fail to find favour with practical engineers, but there are still some adverse opinions as to a few points.

As to the fear of the cylinder being obstructed by dust carried along with the gas, it may be replied that, with properly-designed motors, the mechanical action of dust is practically *nil*, for the fine and almost impalpable powder that remains suspended in the gas after it has been cooled down and freed from the larger matters carried along, has no time to deposit. Again, blast-furnace gas, unlike coal-gas, throws down on cooling no bituminous or sticky deposit. One other fear, that there might be a difficulty in igniting blast-furnace gas, has been proved by practice to be illusory; but, on the contrary, the use of poor gas affords several marked advantages, that of the blast-furnace especially being susceptible of a greater initial compression than rich gas, sufficient indeed to insure its ignition without giving rise to excessive pressures.

The success of motors working with blast-furnace gas can no longer be called in question; and the importance of this conclusion for the iron-industry is enormous. Adopting the moderate estimate of Mr. Lürmann, that 1 ton of pig-iron is accompanied by 163,600 cubic feet (4,633 cubic metres) of gas, having a power of 3,600 British thermal units (906·5 calories), each ton of pig turned out affords 28 horsepower, and the prospect of such a saving as this implies in the cost of producing pig-iron cannot fail to commend itself to ironmasters, who ought immediately to profit by the advantages offered. Nothing is so easily transported or transmitted as gas, and this remark applies even more strongly to blast-furnace than to lighting gas. There will, therefore, be nothing extraordinary if blast-furnace plants in the future are surrounded by works deriving from them the necessary motive power; and this would constitute an additional source of profit to ironmasters.

J. W. P.

A MODEL AERIAL ROPE-WAY.

Mining Lime Rock by Electrically-operated Cable-ways in Open-pit Mining at Rockland and Rockport, Maine. By Frank B. Wright. *Mines and Minerals* [*Scranton, Pa.*], 1899, *vol. xx.*, *pages* 1-4, *with* 6 *illustrations*.

In the lime-producing country about Rockland, Maine, the rock has always been quarried, but the highest grade has been found in wide veins or vertical seams, with the result that most of the quarries have reached a great depth,

several being 300 feet deep, and hoisting-appliances have been in use for many years. As a result of the vein-formation, these open-pit mines are long and narrow, as well as deep. Up to 100 feet in depth, most of them were worked by team-haulage, with long roads descending to the floor of the pit. Afterwards, the horse was replaced by steam-hoists and long-boom derricks, placed on the top-level, and commanding large sections of the pit. These quarries are located at considerable distances from the docks, and conditions of economical production led to establishing limekilns directly on the water's edge. The harbour at Rockland affords a crescent-shaped water-front, and the line of kilns extends in a curve along the wharf-line. The transporting of the crude rock from the quarry to the kilns has been very economically solved by a standard-gauge railroad to connect all the large quarries with these water-front kilns.

The development of long, narrow quarries resulted in the adoption of the horizontal cableway 10 years ago, and two of them are among the first of long-span cableways. Both were equipped with the old-fashioned chain-connected fall-rope carriers, and installed with Lidgerwood engines and boilers. One cableway has a clear span of 975 feet, and ordinarily carries a working load of about 3 tons. An instructive feature about this plant is the use of a 2¼ inches diameter cast-steel cable with 6 strands of 19 wires, a size much in excess of that apparently demanded by the load and span. The resulting record of long-continued service is quite remarkable and most interesting as a testimony to the value of an extra large size of cable for permanent plant in mines. The second cableway has a span of about 850 feet, the same type of carriers, but the main cable differs in being a 1½ inches diameter Elliot locked-coil wire-rope instead of the cast-steel cable. This smooth trackway has greatly reduced the sheave-repair account, as one set of main-cable carriage-sheaves has lasted 4 or 5 years instead of as many weeks, or at the most months, as on an ordinary cable laid up in strands. Electricity has now replaced steam as the motive power, adding to convenience of operation a power whose cost becomes a direct function of the actual rock hoisted, with very small opportunity for waste.

At Rockport, in one of the quarries, the highest development of the modern cableway was installed over a year ago. The cableway has a clear span of 700 feet with a 60 feet head-tower and a 50 feet tail-tower. Both towers are of the familiar four-post type, firmly built of the best yellowpine stock, and fitted with hoods, or shelter-houses, over their tops, an unusual but well-considered provision for the protection of the sheaves and cables in view of the severity of Maine winters. Embraced within the base of the head-tower is the power-house, containing all the machinery for operating the plant. The cableway is operated by a modern electric hoist. The experience with the second plant formed a suggestive basis, and the cable adopted was a 1¾ inches diameter smooth locked-coil rope which, with the usual load of 3 tons, gives a very ample factor of safety. The carriage has the three-track wheels designed so as to prolong the life of the cable by distributing the load. The sheaves have special bushings and large oil-chambers, and all parts of the cableway were designed to handle 8 tons with ease, more than twice the actual load required, with the probable result that this cableway has longer enduring qualities than any hitherto built. The familiar button-stop carriers (Miller patent) have replaced the chain-connected type used on the older cableways in Rockland. The author points out at considerable length the enormous advantages possessed by the newer type of carrier. It is but one-fourth of the weight of the older type, the spacing of the carriers is much greater, so that the stress on

the cable is enormously reduced, hence a much smaller cable suffices when the button-spaced carriers are employed. In addition, the wear-and-tear account is vastly greater in the case of the chain-connected carriers. With respect to the electric hoist, the hoisting-drum, 41 inches in diameter by 25 inches face, and the narrow-faced winch traversing-drum of equal diameter, are arranged on the same shaft, both being friction-drums provided with the ordinary friction and brake levers. These drums are direct-connected to two 1,200 volts motors, armoured type, and the entire construction of drums, gearing, motors, levers and controller is compactly placed on a common bedplate, while the packed plate-resistances are concealed in the bedplate. While one motor at 500 volts and suitable ampèrage would handle the usual load of 3 tons, the advantage of the double-motor construction is secured by the use of a series-parallel controller, by which means the torque and speed may be varied so as to start a load quickly at slow speed and gradually accelerate to full speed. This is of special value in cablework, where by its aid the speed of traversing may be greatly increased over that of hoisting. This electric hoist has proved practically noiseless, very easily handled, and quick; and the motors run absolutely cool with no sign of heating. The power is furnished at a lower figure than the cost of the coal that a steam-hoist would consume. The services of a fireman are saved, and the reduction in repair, and ease and convenience of handling, all combine to produce the highest economy. The conditions at the second and third quarries, respectively, are quite the same with regard to incline of cable and load handled, and the electric power is furnished under the same circumstances. Both cables are locked-coil ropes, affording equally smooth trackways, but in addition to the diminshed first cost, and the less cost of repairs in the case of the newer plant, the fact remains that with regard to the even more important item of power consumed in the daily operations, the older plant is worked only by an expenditure of power which is 25 per cent. greater than that absorbed by the newer plant of the Shepherd Company.

X. Y. Z.

CHECKING MINERS AT WORK.

"*Die Markencontrole,*" *eingeführt beim Steinkohlenbergbau Heinrichsglück-Zeche in Peterswald. By* Richard Danilof. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen,* 1897, *vol. xlv., pages* 172-173.

A new system of checking miners' tallies has lately been introduced in a coal-mine near Peterswald in Bohemia. To each miner is given a number corresponding to that on his lamp, and this number is entered in the books. On their arrival at the shaft, the miners each receive a tally pierced with a hole, which a foreman gives them out of a box. They enter the cage in the order in which they have come, and on reaching the pit-bottom they give up their tallies to another foreman. Each tally as it is returned is filed in the same way as an invoice. When the shift is over, the file is turned over, and the tallies presented in the reverse order for redistribution, thus the miner who first enters is the first to leave the mine. When all the shift have gone down, a controller enters in his book the numbers of all the tallies remaining in the box at the top of the shaft, which represent the miners who have not descended. To some of these tallies others of different kinds are now affixed. For instance, if a miner reports himself, but does not go down the shaft, the tally bearing his number has another marked U (*urlaub* or leave) attached to it, and the controller writes U against the man's number in his book. If the

letter K (*krank* or sick) is affixed, the man is so written down. All tallies not thus treated are marked O (*ohne urlaub* or absent without leave). Sometimes, if miners have been detained aboveground for loading, discharging, etc., their tallies are neither in the box, nor have they been given up at the pit-bottom. Hence the controller, after writing down the number, inquires in the lamp-room whether all the miners whose tallies are not in the box have gone down. If their lamps are still there, the controller then traces the whereabouts of the men aboveground. As the overmen and foremen have also tallies, the names of all in the mine are known, and this is very important in case of accidents. With a shift of 230 men, it only takes ¼ hour for the controller to check the tallies.

On leaving the shaft, the miners receive their tallies back and deliver them up to a foreman aboveground, who immediately hangs them up in order in the office, and thus it is known whether all the men of a shift have come up. If any tallies are missing, search is at once made for the corresponding man in the pit, and a simple means is thus afforded of checking the movements of a large body of men. There is also much less delay in sending the miners down than formerly, because it is not necessary first to take down their names. It is even to their interest to descend as quickly as possible, because if they are the first to go down they will also come up first.

The miners' book is made up by the head foreman, who is alone responsible for the distribution of the men in the different pits. If a miner is reported absent from a pit by his overman, the foreman will know to which shaft he has been sent. As it takes only ¼ hour to get the miners into the pit, they are not required to come quite as early as formerly. By degrees they get into the way of leaving their work in the mine, and presenting themselves at the shaft at the right time, as they know pretty well the order in which they have come.

The system works well, ensures order and discipline among the men, and it is said that difficulties and complications are avoided. B. D.

ANKYLOSTOMASIA, OR MINERS' ANÆMIA.

Note sur l'Ankylostomasie, Maladie Parasitaire des Mineurs. *By* DR. CH. RŒRSCH. *Revue Universelle des Mines*, 1899, *vol. xlv.*, *pages* 59-72.

The duodenal ankylostoma is one of the most formidable parasites that can attack the human organism, attaching itself to the mucous membrane, poisoning the system, and abstracting so much blood that death may ensue after symptoms of profound anæmia. The conditions favourable to the development of the ova and larvæ are a damp medium, the absence of light, and a temperature of about 81½° Fahr. (25° to 30° Cent.), conditions which especially obtain in mines, while a higher or a lower temperature prevents the ova from arriving at maturity.

The first symptoms, which appear about 6 weeks after the ingestion of the larvæ, comprize troubles of the digestive organs, accompanied by epigastric pain and oppression, followed by serious anæmia, paleness of countenance, diminution of power, perspiration on the least effort, vertigo, syncope, palpitation and a feeling of suffocation. Fortunately the diagnosis is easy, being limited to microscopic examination of the dejections for tracing the ova; and the treatment consists in repeated administration of the ethereal extract of the male fern, spontaneous recovery being rare, if indeed it be possible.

This parasite was discovered in 1838 by Dr. Dubini; and in 1880 Dr. Perroncito showed that the special form of anæmia which attacked the workmen driving the St. Gothard tunnel was of parasitic origin. In 1885, Drs. Francotte and Masius found the ankylostoma in the collieries of the Liége district, Mr. Van Beneden in that of Mons, and Mr. Mayer in that of Aix-la-Chapelle, while in Bavaria there was quite an epidemic of ankylostomasia. A few years ago, the Brennberg colliery in Hungary was free from this malady; but quite recently 80 per cent. of the workmen were attacked, so that it is high time to take measures against its propagation and to apply them energetically.

A colliery becomes infected by the dejections of workmen suffering from the disease; and in a few days an innumerable number of larvæ are developed. By walking in the infected matters the men disseminate them and deposit the larvæ in the mud, while the water becomes contaminated; and the mud and water, containing the larvæ, by soiling the shoes, clothes, tools, timbers, and therefore the men's hands, multiply the causes of infection. If their fingers are dirty, the men may very easily carry to their mouth a few larvæ while eating, wiping the face, etc. If only 2 or 3 workmen are taken ill the dissemination of the ova and larvæ may proceed rapidly. In the Dortmund mining district, out of 56,870 workmen at 38 collieries, 275 were found to be suffering from ankylostomasia; but in many mines employing more than 2,000 men only one was found to be attacked.

In the case of mines already infected the following measures are calculated to prevent the infection from extending to fresh cases:—

(1) The mine should be cleansed as far as possible, and the timbering, if damp, white-washed.

(2) A knowledge of the malady, its main symptoms and its dangers, as well as of all preventive measures, should be disseminated among the men by all possible means.

(3) Portable sanitary appliances, with well-fitting covers and ample provision of antiseptic powder, should be provided at convenient places underground, and the workmen strictly enjoined to use them exclusively.

(4) The workings should be maintained in the highest possible state of cleanliness.

(5) The workmen should be enjoined to raise their fingers to the mouth as little as possible, holding their food by the clean paper in which it was wrapped.

(6) Clean water for washing should be provided in abundance.

J. W. P.

EXPLOSION OF DYNAMITE IN KIMBERLEY MINE.

Eleventh Annual Report of the De Beers Consolidated Mines, Limited, for the Year ending June 30th, 1899, page 7.

An explosion of dynamite occurred in the magazine in the Kimberley mine on June 9th, 1899, at 9.5 a.m. on the 1,480 feet level. One white man and 29 natives were killed or died from the effects of injuries received. Nine white men working on the 1,480 and 1,440 feet levels were more or less severely injured, and a number of others were affected by the dynamite fumes.

The magazine contained 255 pounds of dynamite, together with one or two boxes of detonators: this quantity being a 24 hours' supply. Five cases of the dynamite were placed in the magazine about 40 minutes prior to the

time when the explosion occurred. The magazine, constructed of wood, was situated in one of the offsets, and contained three boxes, one for dynamite, one for detonators, and the third for candles. The outside door was painted red to denote the dangerous nature of the contents, and was kept locked. The explosive and fuses were carried about the mine in separate boxes, so that they should not be brought in contact before being used. There had been no blasting in that part of the mine for a considerable time before the explosion occurred.

The damage to the mine was immaterial. About 175 feet of timbering in one of the main tunnels, and 89 feet in another tunnel were destroyed. It was suggested that by some means the dynamite was set afire and that after burning for a short time it had exploded. The temperature of the mine, on the day following the explosion was 73° Fahr.

M. W. B.

II.—REPORT OF THE CORRESPONDING SOCIETIES COMMITTEE OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, DOVER, 1899.*

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The following Corresponding Societies nominated as delegates to represent them at the Dover meeting:—The Institution of Mining Engineers, Prof. Henry Louis; Midland Institute of Mining, Civil and Mechanical Engineers, Prof. Henry Louis; North of England Institute of Mining and Mechanical Engineers, Mr. J. H. Merivale; Mining Institute of Scotland, Mr. James Barrowman; South Staffordshire and East Worcestershire Institute of Mining Engineers, Prof. Henry Louis.

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First Meeting of the Conference, Dover, September 14, 1899.

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Second Meeting of the Conference, September 19, 1899.

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SECTION A.

Mr. G. J. Symons, representing Section A, said that the Committee for Seismological Observations were badly in want of a home, and would be very glad if some ancient building could be allotted to them.

SECTION C.

The Chairman, representing Section C, could mention two investigations in which the local societies had been of much assistance. The Committee to investigate the Erratic Blocks of the British Isles presented a Report this year. The Committee for the Collection, Preservation and Systematic Registration of Photographs of Geological Interest, of which he was secretary, would be glad to receive any contributions of such photographs. The Committee hoped to be able to undertake the publication of typical geological photographs in such a way as to render them easily obtainable by those who could make good use of them. It would greatly help the Committee if local societies would agree to purchase a series of these photographs. There was also a duplicate collection of prints and lantern slides which could be sent to any local society wishing to exhibit them and to see what kind of work was being done, the only expense incurred by the society being that of carriage. They proposed, when publishing the photographs, to add letterpress descriptions.

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Committees appointed by the General Committee at the Dover Meeting in September, 1899.

1.—Receiving Grants of Money.

Subject for Investigation or Purpose.	Members of the Committee.	Grants.
		£ s. d.
Seismological observations	*Chairman.*—Prof. J. W. Judd. *Secretary.*—Prof. J. Milne. Lord Kelvin, Sir F. J. Bramwell, Prof. G. H. Darwin, Mr. Horace Darwin, Major L. Darwin, Prof. J. A. Ewing, Prof. C. G. Knott, Prof. R. Meldola, Prof. J. Perry, Prof. J. H. Poynting, Prof. T. G. Bonney, Mr. C. V. Boys, Prof. H. H. Turner, Mr. G. J. Symons, Mr. Clement Reid, Mr. R. D. Oldham, and Mr. W. E. Plummer.	60 0 0
The nature of alloys	*Chairman and Secretary*—Mr. F. H. Neville. Mr. C. T. Heycock, and Mr. E. H. Griffiths.	30 0 0
To investigate the erratic blocks of the British Isles, and to take measures for their preservation. [6*l.* in hand.]	*Chairman.*—Prof. E. Hull. *Secretary.*—Prof. P. F. Kendall. Prof. T. G. Bonney, Mr. C. E. De Rance, Prof. W. J. Sollas, Mr. R. H. Tiddeman, Rev. S. N. Harrison, Mr. J. Horne, Mr. Dugald Bell, Mr. F. M. Burton, Mr. J. Lomas, Mr. A. R. Dwerryhouse, Mr. J. W. Stather, and Mr. R. D. Tucker.	—
The collection, preservation and systematic registration of photographs of geological interest.	*Chairman.*—Prof. J. Geikie. *Secretary.*—Prof. W. W. Watts. Prof. T. G. Bonney, Dr. T. Anderson, and Messrs. A. S. Reid, E. J. Garwood, W. Gray, H. B. Woodward, R. Kidston, J. J. H. Teall, J. G. Goodchild, H. Coates, C. V. Crook, G. Bingley, and R. Welch.	10 0 0
Corresponding Societies Committee for the preparation of their report.	*Chairman.*—Prof. R. Meldola. *Secretary.*—Mr. T. V. Holmes. Mr. Francis Galton, Mr. G. J. Symons, Dr. J. G. Garson, Sir John Evans, Mr. J. Hopkinson, Prof. T. G. Bonney, Mr. W. Whitaker, Sir Cuthbert E. Peek, Mr. Horace T. Brown, Rev. J. O. Bevan, Prof. W. W. Watts, and Rev. T. R. R. Stebbing.	20 0 0
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2.—Not Receiving Grants of Money.

Subject for Investigation or Purpose.	Members of the Committee.
To confer with British and foreign societies publishing mathematical and physical papers as to the desirability of securing uniformity in the size of the pages of their transactions and proceedings.	*Chairman.*—Prof. S. P. Thompson. *Secretary.*—Mr. J. Swinburne. Prof. G. H. Bryan, Mr. C. V. Burton, Mr. R. T. Glazebrook, Prof. A. W. Rücker, and Dr. G. Johnstone Stoney.
The rate of increase of underground temperature downwards in various localities of dry land and under water.	*Chairman.*—Prof. J. D. Everett. *Secretary.*—Prof. J. D. Everett. Lord Kelvin, Mr. G. J. Symons, Sir Archibald Geikie, Mr. J. Glaisher, Prof. Edward Hull, Dr. C. Le Neve Foster, Prof. A. S. Herschel, Prof. G. A. Lebour, Mr. A. B. Wynne, Mr. W. Galloway, Mr. Joseph Dickinson, Mr. G. F. Deacon, Mr. E. Wethered, Mr. A. Strahan, Prof. Michie Smith, and Prof. H. L. Callendar.
To consider the best methods for the registration of all type specimens of fossils in the British Isles, and to report on the same.	*Chairman.*—Dr. H. Woodward. *Secretary.*—Mr. A. Smith Woodward. Rev. G. F. Whidborne, Mr. R. Kidston, Prof. H. G. Seeley, and Mr. H. Woods.
The collection, preservation and systematic registration of Canadian photographs of geological interest.	*Chairman.*—Prof. A. P. Coleman. *Secretary.*—Mr. Parks. Prof. A. B. Willmott, Prof. F. D. Adams, Mr. J. B. Tyrrell and Prof. W. W. Watts.
To study life-zones in the British Carboniferous rocks.	*Chairman.*—Mr. J. E. Marr. *Secretary.*—Dr. Wheelton Hind. Mr. F. A. Bather, Mr. G. C. Crick, Mr. A. H. Foord, Mr. H. Fox, Mr. E. J. Garwood, Dr. G. J Hinde, Prof. P. F. Kendall, Mr. J. W. Kirkby, Mr. R. Kidston, Mr. G. W. Lamplugh, Prof. G. A. Lebour, Mr. G. H. Morton, Mr. B. N. Peach, Mr. A. Strahan, and Dr. H. Woodward.
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THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1899–1900.

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Andersonian Naturalists' Society, 1885	Andersonian Nat. Soc.	204, George Street, Glasgow. R. Barnett Johnstone	172	None	2s. 6d.	Annals, occasionally.
Bath Natural History and Antiquarian Field Club, 1855	Bath N. H. A. F. C. ..	Rev. W. W. Martin, Royal Literary and Scientific Institution, Bath	100	5s.	10s.	Proceedings, annually.
Belfast Natural History and Philosophical Society, 1821	Belfast N. H. Phil. Soc.	Museum, College Square. R. M. Young, B.A.	252	None	£1 1s.	Report and Proceedings, annually.
Belfast Naturalists' Field Club, 1863..	Belfast Nat. F. C. ..	Museum, College Square. William Gray and Dr. W. D. Donnan	400	5s.	5s.	Report and Proceedings, annually.
Berwickshire Naturalists' Club, 1831..	Berwicksh. Nat. Club ..	Rev. G. Gunn, M.A., Stichill, Kelso, N.B.	400	10s. 6d.	7s. 6d.	History of the Berwickshire Naturalists' Club, annually.
Birmingham Natural History and Philosophical Society, 1858	Birm. N. H. Phil. Soc.	Norwich Union Chambers, Congreve Street, Birmingham. W. P. Marshall and P. L. Gray	254	None	£1 1s.	Proceedings, annually.
Brighton and Hove Natural History and Philosophical Society, 1854	Brighton N. H. Phil. Soc.	Museum, Church Street, Brighton. E. A. Pankhurst	186	10s.	10s.	Report, annually.
Bristol Naturalists' Society, 1862 ..	Bristol Nat. Soc. ..	Theodore Fisher, M.D., 25, Pembroke Road, Clifton, Bristol	157	5s.	10s.	Proceedings, annually.
Buchan Field Club, 1887	Buchan F. C.	J. F. Tocher, F.I.C., 5, Chapel Street, Peterhead	160	5s.	5s.	Transactions, annually.
Burton-on-Trent Natural History and Archæological Society, 1876	Burt. N. H. Arch. Soc..	B. L. Oswell, 30, High Street, Burton-on-Trent	220	None	5s.	Annual Report. Transactions, occasionally
Caradoc and Severn Valley Field Club, 1893	Car. & Sev. Vall. F. C...	H. E. Forrest, 37, Castle Street, Shrewsbury	180	5s.	5s.	Transactions and Record of Bare Facts, annually.
Cardiff Naturalists' Society, 1867 ..	Cardiff Nat. Soc. ..	Walter Cook, 98, St. Mary Street, Cardiff	450	None	10s. 6d.	Transactions, annually.
Chester Society of Natural Science and Literature, 1871	Chester Soc. Nat. Sci...	Grosvenor Museum, Chester. G. P. Miln and W. F. J. Shepheard	808	None	5s.	Annual Report. Proceedings, occasionally.
Chesterfield and Midland Counties Institution of Engineers, 1871	Chesterf. Mid. Count. Inst.	Stephenson Memorial Hall. G. A. Lewis, Albert Street, Derby	353	£1 1s. None	Members, 31s. 6d.; Associates and Students, 20s.	"Transactions of The Institution of Mining Engineers," monthly.
Cornwall, Mining Association and Institute of, 1859	Cornw. Min. Assoc. Inst.	William Thomas, C.E., F.G.S., Penelvan, Camborne	200	10s. 6d.	Minimum, 10s. 6d.	Transactions, annually.
Cornwall, Royal Geological Society of, 1814	Cornw. R. Geol. Soc. ..	The Museum, Public Buildings, Penzance. John B. Cornish	98	None	£1 1s.	Report and Transactions, annually
Croydon Microscopical and Natural History Club, 1870	Croydon M. N. H. C. ..	Public Hall, Croydon. R. F. Grundy	230	None	10s.	Proceedings and Transactions, annually.
Dorset Natural History and Antiquarian Field Club, 1875	Dorset N. H. A. F. C...	Nelson M. Richardson, Montevideo, Chickerel, Weymouth	350	None	10s.	Proceedings, annually.
Dublin Naturalists' Field Club, 1885..	Dublin N. F. C.	Prof. T. Johnson, D.Sc., and N. H. Alcock, M.D., Royal Irish Academy, Dublin	200	5s.	5s.	"Irish Naturalist," monthly. Report, annually.
Dumfriesshire and Galloway Natural History and Antiquarian Society, 1862	Dum. Gal. N. H. A. Soc.	Dr. J. Maxwell Ross, St. Ruths, Dumfries	186	2s. 6d.	5s.	Transactions and Journal of Proceedings, annually.
East Kent Scientific and Natural History Society, 1857	E. Kent S. N. H. Soc...	H. Mead Briggs, 8, High Street, Canterbury	67	None	10s.	"South Eastern Naturalist," and Annual Report.

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1899-1900.—*Continued.*

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Edinburgh Geological Society, 1834..	Edinb. Geol. Soc. ..	5, St. Andrew Square, Edinburgh. James Currie	267	10s. 6d.	12s. 6d.	Transactions, annually.
Essex Field Club, 1880	Essex F. C.	William Cole, 7, Knighton Villas, Buckhurst Hill, Essex	300	None	15s.	"Essex Naturalist," quarterly, and "Special Memoirs," occasionally.
Glasgow, Geological Society of, 1858	Glasgow Geol. Soc. ..	J. Barclay Murdoch, Capelrig, Mearns, Glasgow	216	None	10s.	Transactions, annually.
Glasgow, Natural History Society of, 1851	Glasgow N. H. Soc. ..	S. M. Wellwood and R. D. Wilkie, 207, Bath Street, Glasgow	319 Members 25 Associates	None	Members 7s. 6d. Associates 5s	Transactions and Proceedings, annually
Glasgow, Philosophical Society of, 1802	Glasgow Phil. Soc. ..	Freeland Fergus, M.D., 207, Bath Street, Glasgow	653	£1 1s.	£1 1s.	Proceedings, annually.
Halifax Scientific Society and Geological Field Club, 1874	Halifax S. S. G. F. C. .	Literary and Philosophical Society's Rooms. F. Barker and W. E. Jenkinson	111	None	2s. 6d.	"Halifax Naturalist," every two months.
Hampshire Field Club and Archaeological Society, 1885	Hants. F. C.	Hartley Institution, Southampton. W. Dale, F.G.S.	250	None	7s. 6d.	Proceedings, annually.
Hertfordshire Natural History Society and Field Club, 1875	Herts. N. H. Soc. ..	John Hopkinson, F.L.S., The Grange, St. Albans	210	10s.	10s.	Transactions, quarterly.
Holmesdale Natural History Club, 1857	Holmesdale N. H. C. ..	A. J. Crosfield, Carr End, Reigate	88	10s.	10s.	Proceedings, every two or three years.
Hull Geological Society, 1887	Hull Geol. Soc. .. .	Royal Institution. John W. Stather	65	None	5s.	Transactions, annually.
Institution of Mining Engineers ..	Inst. Min. Eng. ..	M. Walton Brown, Neville Hall, Newcastle-upon Tyne	2,500	None	None	Transactions, monthly.
Inverness Scientific Society and Field Club, 1875	Inverness Sci. Soc. .	E. G. Critchley, 29, High Street, Inverness	175	None	5s. and 2s.	Transactions, occasionally.
Ireland, Statistical and Social Inquiry Society of, 1847	Stat. Soc. Ireland ..	J. Pim, W. Lawson and C. H. Oldham, 35, Molesworth Street, Dublin	100	None	£1.	Journal, annually.
Leeds Geological Association, 1874 ..	Leeds Geol. Assoc. ..	Philosophical Hall, Leeds. W. Parsons	93	None	5s.	Transactions, occasionally.
Leeds Naturalists' Club and Scientific Association, 1868	Leeds Nat. C. Sci. Assoc.	H. B. Wilson, Westfield, Armley, Leeds	153	None	6s.	Transactions, occasionally.
Leicester Literary and Philosophical Society, 1835	Leicester Lit. Phil. Soc.	Corporation Museum. J. M. Gimson	320 Members & Associates.	None	Members, £1 1s.; Associates, 10s. 6d.	Transactions, quarterly.
Liverpool Engineering Society, 1875..	Liv'pool E. Soc.	R. C. F. Annett, Royal Institution, Liverpool	402	None	Resident, £1 1s.; Non-res., and Students, 10s. 6d.	Transactions, annually.
Liverpool Geographical Society, 1891	Liv'pool Geog. Soc. ..	Capt. E. C. Dubois Phillips, R.N., 14, Hargreave's Buildings, Chapel Street, Liverpool	750	None	£1 1s.	Transactions and Report, annually.
Liverpool Geological Society, 1858 ..	Liv'pool Geol. Soc. ..	Royal Institution. H. C. Beasley	55	None	£1 1s.	Proceedings, annually.
Liverpool, Literary and Philosophical Society of, 1812	Liv'pool Lit. Phil. Soc..	Royal Institution. J. Maxwell McMaster	214	None	£1 1s.; Ladies, 10s. 6d.	Proceedings, annually.
Malton Field Naturalists' and Scientific Society, 1879	Malton F. N. Sci. Soc...	Museum, Yorkersgate, Malton, Yorkshire. Rev. F. J. R. Young	96	None	5s. and 2s. 6d.	Report, annually.

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1899–1900.—*Continued.*

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Man, Isle of, Natural History and Antiquarian Society, 1879	I. of Man N. H. A. Soc.	P. M. C. Kermode, Hillside, Ramsey, Isle of Man	154	2s. 6d.	Gentlemen, 7s. 6d. Ladies and Non-Residents, 5s.	Yn Lioar Manninagh, biennially.
Manchester Geographical Society, 1884	Manch. Geog. Soc. ..	Eli Sowerbutts, F.R.G.S., 16, St. Mary's Parsonage, Manchester	700	None	Members, £1 1s.; Associates, 10s. 6d.	Journal, quarterly; "Geography," monthly
Manchester Geological Society, 1838..	Manch. Geol. Soc. ..	5, John Dalton Street, Manchester. W. Saint and C. R. Lindsey	240	None	£1.	Transactions, eight or nine parts per annum.
Manchester Microscopical Society, 1880	Manch. Mic. Soc. ..	E. C. Stump, 16, Herbert Street, Moss Side, Manchester	210	5s.	6s.	Transactions and Report annually.
Manchester Statistical Society, 1833..	Manch. Stat. Soc. ..	63, Brown Street, Manchester. F. E. M. Beardsall and T. Gregory	204	10s. 6d.	10s. 6d.	Transactions, annually.
Marlborough College Natural History Society, 1864	Marlb. Coll. N. H. Soc.	Marlborough College. E. Meyrick ..	337	1s. 6d.	3s. and 5s.	Report, annually.
Midland Institute of Mining, Civil and Mechanical Engineers, 1869	Midland Inst Eng. .	T. W. H. Mitchell, Mining Offices, Regent Street, Barnsley	253	None	£1 10s.	"Transactions of The Institution of Mining Engineers," monthly.
Norfolk and Norwich Naturalists' Society, 1869	Norf. Norw. Nat. Soc.	W. A. Nicholson, St. Helen's Square, Norwich	255	None	5s.	Transactions, annually.
North of England Institute of Mining and Mechanical Engineers, 1852	N. Eng. Inst.	M. Walton Brown, Neville Hall, Newcastle-upon-Tyne	1,200	None	21s. and 42s.	"Transactions of The Institution of Mining Engineers," monthly.
North Staffordshire Field Club .	N. Staff. F. C. .. .	Rev. T. W. Daltry, M.A., Madeley Vicarage, Newcastle, Staffs.; W. Wells Bladen, Stone, Staffs.	433	5s.	5s.	Report and Transactions, annually.
Northamptonshire Natural History Society and Field Club, 1876	N'ton N. H. Soc. ..	H. N. Dixon, M.A., 23, East Park Parade, Northampton	160	None	10s.	Journal, quarterly.
Nottingham Naturalists' Society, 1852	Nott. Nat. Soc.	Prof. J. W. Carr, University College, Nottingham	160	2s. 6d.	5s.	Report, annually.
Paisley Philosophical Institution, 1808	Paisley Phil. Inst. ..	J. Gardner, 3, County Place, Paisley	350 20 Associates	5s.	7s. 6d.	Report, annually; Meteorological Observations, occasionally.
Penzance Natural History and Antiquarian Society, 1839	Penz. N. H. A. Soc. ..	Museum, Public Buildings, Penzance. Dr. H. M. Montgomerie	71	None	10s. 6d.	Report, annually; Transactions, occasionally.
Perthshire Society of Natural Science, 1867	Perths. Soc. N. Sci. ..	Tay Street, Perth. S. T. Ellison ..	374	2s. 6d.	5s. 6d.	Transactions and Proceedings, annually.
Rochdale Literary and Scientific Society, 1878	Rochdale Lit. Sci. Soc.	J. Reginald Ashworth, B.Sc., 105, Freehold Street, Rochdale	239	None	6s.	Transactions, biennially.
Rochester Naturalists' Club, 1878 ..	Rochester N. C.	John Hepworth, Linden House, Rochester	144	None	5s.	"Rochester Naturalist," quarterly.
Scotland, Mining Institute of, 1878 ..	Mining Inst. Scot. ..	James Barrowman, Staneacre, Hamilton, N.B.	468	None	42s. and 25s.	"Transactions of The Institution of Mining Engineers," monthly.
Somersetshire Archæological and Natural History Society, 1848	Som'setsh. A.N.H. Soc.	The Castle, Taunton. Lt.-Col. J. R. Bramble and Rev. F. W. Weaver	633	10s. 6d.	10s. 6d.	Proceedings, annually.

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1899-1900.—*Continued.*

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South African Philosophical Society, 1877	S. African Phil. Soc. ..	L. Péringuey, South African Museum, Cape Town	126	None	£2 and £1.	Transactions, annually.
South-Eastern Union of Scientific Societies, 1896	S.-E. Union	George Abbott, M.R.C.S., 33, Upper Grosvenor Road, Tunbridge Wells	32 Societies; 4,549 Members	None	5s.	Transactions, annually.
South Staffordshire and East Worcestershire Institute of Mining Engineers, 1867	S. Staff. Inst. Eng. ..	Alexander Smith, M. Inst. C.E., 3, Newhall Street, Birmingham	178	£1 1s. and 10s. 6d.	31s. 6d. and 21s.	"Transactions of The Institution of Mining Engineers," monthly.
Toronto, Astronomical and Physical Society of, 1884	Toronto Astr. Phys. Soc.	Technical School Buildings. Thos. Lindsay	120	None	2 dollars.	Transactions, annually.
Tyneside Geographical Society, 1887 ..	Tyneside Geog. Soc. ..	Geographical Institute, Barras Bridge, Newcastle-upon-Tyne. Herbert Shaw, B.A.	1,200	None	10s. and 5s.	Journal, half-yearly.
Warwickshire Naturalists' and Archæologists' Field Club, 1854	Warw. N. A. F. C. ..	Museum, Warwick. T. W. Whitley, 20, Camberwell Terrace, Leamington	94	2s. 6d.	5s.	Proceedings, annually.
Woolhope Naturalists' Field Club, 1851	Woolhope N. F. C. ..	Woolhope Club Room, Free Library, Hereford. H. Cecil Moore	212	10s.	10s.	Transactions, biennially.
Yorkshire Geological and Polytechnic Society, 1837	Yorks. Geol. Poly. Soc.	Rev. Wm. Lower Carter, F.G.S., Hopton, Mirfield	157	None	13s.	Proceedings, annually.
Yorkshire Naturalists' Union, 1861 ..	Yorks. Nat. Union ..	W. Denison Roebuck, F.L.S., 259, Hyde Park Road, Leeds	438 and 2,446 Associates	None	10s. 6d.	Transactions, annually; "The Naturalist," monthly.
Yorkshire Philosophical Society, 1822	Yorks. Phil. Soc. ..	Museum, York. Dr. Tempest Anderson and C. E. Elmhirst	420	None	£2	Report, annually.

LIST OF THE MORE IMPORTANT PAPERS, AND ESPECIALLY THOSE REFERRING TO LOCAL SCIENTIFIC INVESTIGATIONS, PUBLISHED BY NAMED SOCIETIES DURING THE YEAR ENDING JUNE 1, 1899.*

Section A.—MATHEMATICAL AND PHYSICAL SCIENCE.

DIXON, H. N. "The Divining Rod." *Journal N'ton N. H. Soc.*, vol. x., pages 85-104, 1898.

MANTELL, SURGEON-MAJOR A. A. "On some supposed Electrical Phenomena in Water-finding." *Proc. Bath N. H. A. F. C.*, vol. ix., pages 101-109, 1899.

MOORE, H. CECIL, ROBERT CLARK. and ALFRED WATKINS. "The Earthquake of December 17, 1896." *Trans. Woolhope N. F. C.*, *1895-97*, pages 228-235, 1898.

THOMPSON, BEEBY. "The Divining Rod." *Journ. N'ton. N. H. Soc.*, vol. x., pages 105-111, 1898.

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Section B.—CHEMISTRY.

ANDERSON, W. CARRICK. "A Contribution to the Chemistry of Coal, with special reference to the Coals of the Clyde Basin." *Proc. Glasgow Phil. Soc.*, vol. xxix., pages 72-96, 1898; *Trans. Inst. Min. Eng.*, vol. xvi., pages 335-357, 1899.

BEDSON, PROF. P. PHILIPS (N. Eng. Inst.). "Results of the Analysis of Samples of New Zealand Coal and Ambrite, and of Barbados Manjak." *Trans. Inst. Min. Eng.*, vol. xvi., pages 388-390, 1898.

BREAKALL, J. E. "Treatment of Refractory Silver-ores by Chlorination and Lixiviation." *Ibid.*, pages 316-330, 1899.

BURRELL, B. A. "The Composition of the Spar occurring in Mother Shipton's Cave, Knaresborough." *Proc. Yorks. Geol. Poly. Soc.*, vol. xiii., pages 284-285, 1898.

HALDANE, DR. JOHN S., and F. G. MEACHAM (S. Staff. Inst. Min. Eng.) "Observations on the Relation of Underground Temperature and Spontaneous Fires in the Coal to Oxidation and to the Causes which favour it." *Trans. Inst. Min. Eng.*, vol. xvi., pages 457-492, 1899.

HEISE and THIEM, MESSRS. "Experiments on the Ignition of Fire-damp and Coal-dust by Electricity." *Ibid.*, vol. xvii, pages 88-116, 1899.

ORSMAN, WM. JAS. "Safety-explosives." *Ibid.*, vol. xvii., pages 54-59, 1899.

PICARD, HUGH K. "The Direct Treatment of Auriferous Mispickel-ore by the Bromo-Cyanide Process at Deloro, Ontario, Canada." *Ibid.*, vol. xv., pages 417-433, 1898.

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Section C.—GEOLOGY.

BAIN, H. FOSTER (N. Eng. Inst.) "The Western Interior Coal-field of America." *Trans. Inst. Min. Eng.*, vol. xvi., pages 185-210, 1898.

BARKE, F. "Report of the Geological Section." *Trans. N. Staff. F. C.*, vol. xxxiii, pages 65-66, 1899.

BARRON, T. "On a new British Rock containing Nepheline and Riebeckite [1896.]" *Hist. Berwicksh. Nat. Club.*, vol. xvi., pages 92-100, 1898.

BATES, J. I. "The Geology of Swanage and Neighbouring District." *Proc. Warw. N. A. F. C.*, part 43, pages 14-32, 1899.

* The Titles of Papers on other than Mining or Mechanical Engineering, etc., have not been reprinted.

BEASLEY, H. C. "Notes on Examples of Footprints, etc., from the Trias in some Provincial Museums." *Proc. Liverpool Geol. Soc.*, vol. viii., pages 233-237, 1898.

— "A Section of the Trias recently exposed on Prenton Hill." *Ibid.*, vol. viii., pages 238-241, 1898.

BECHER, S. J. (N. Eng. Inst.). "The Nullagine District, Pilbarra Goldfield, Western Australia. *Trans. Inst. Min. Eng.*, vol. xvi., pages 44-51, 1898.

BREWER, WM. M. "Mining in British Columbia." *Ibid.*, vol. xv., pages 455-459, 1898.

BRIART, A. "The Mining Industry of Belgium." *Ibid.*, pages 470-490.

BURTON, F. M. "Boulders at Brigg." *The Naturalist* for 1898, pages 257-258, 1898.

— "Lincolnshire Coast Boulders." *The Naturalist* for 1899, pages 105-111, 1899.

CADELL, HENRY M. "On an Ash Neck in the Broxburn Shale Workings at Philpstoun." With an Appendix by J. S. FLETT. *Trans. Edinb. Geol. Soc.*, vol. vii., pages 477-481, 1899.

CHURCHILL, FRANK F. "Notes on the Geology of the Drakensbergen, Natal." *Trans. S. African Phil. Soc.*, vol. x., pages 419-426, 1899.

CLOUGH, C. T., and ALFRED HARKER. "On a Coarsely Spherulitic (Variolitic) Basalt in Skye." *Trans. Edinb. Geol. Soc.*, vol. vii., pages 381-389, 1899.

COLLINS, J. H. "Notes on Cornish Fossils in the Penzance Museum." *Trans. Cornw. R. Geol. Soc.*, vol. xii., pages 233-240, 1899.

CURRIE, JAMES. "Note on the Feldspars of Canisp." *Trans. Edinb. Geol. Soc.*, vol. vii., pages 494-496, 1899.

DAWSON, CHARLES. "Natural Gas in Sussex." *Trans. S.-E. Union*, vol. iii., pages 73-80, 1898.

DE RANCE, C. E. "The Occurrence of Anhydrite in the North of England, &c." *Trans. Inst. Min. Eng.*, vol. xvii., pages 75-84, 1899.

DICKENSON, JOSEPH. "Subsidence caused by Colliery Workings." *Trans. Manch. Geol. Soc.*, vol. xxv., 583-612, 1898.

ELWEN, T. L. (N. Eng. Inst.). "Notes on the Glacial Deposit or Wash of the Dearness Valley. *Trans. Inst. Min. Eng.*, vol. xvii., pages 226-229, 1899.

FLETT, JOHN S. "On Phenocrysts of Micropegmatite." *Trans. Edinb. Geol. Soc.*, vol. vii., pages 482-487, 1899.

FOORD, Dr. ARTHUR H. (Dublin N.F.C.). "The Brachiopoda and Mollusca of the Carboniferous Rocks of Ireland: Irish Fossil Shells, and their Modern Representatives." *Irish Naturalist*, vol. viii., pages 68-86, 1899.

FOX, HOWARD. "Supplementary Notes on the Cornish Radiolarian Cherts and Devonian Fossils." *Trans. Cornw. R. Geol. Soc.*, vol. xii., pages 278-282, 1899.

FOX-STRANGEWAYS, C. "Notes on the Coast Sections between Hayburn Wyke and Filey." *Proc. Yorks. Geol. Poly. Soc.*, vol. xiii., pages 356-357, 1898.

GASCOYNE, ROWLAND, and G. BLAKE WALKER (Midland Inst. Eng.). "The Coalfields of Chili." *Trans. Inst. Min. Eng.*, vol. xv., pages 234-242, 244-249, 1898.

GREEN, UPFIELD. "On some New and Peculiar Fossils from the Lower Devonians of the South Coast of Cornwall." *Trans. Cornw. R. Geol. Soc.*, vol. xii., pages 227-228, 1899.

GREENLY, EDWARD. "The Hereford Earthquake of December 17, 1896, considered in relation to Geological Structure in the Bangor-Anglesey Region." *Trans. Edinb. Geol. Soc.*, vol. vii., pages 469-476, 1899.

GUNN, WILLIAM. "Notes on the Correlation of the Lower Carboniferous Rocks of England and Scotland." *Ibid.*, vol. vii., pages 361-367, 1899.

HARKER, ALFRED. "Chemical Notes on Lake District Rocks: I. The Ordovician Volcanic Series. II. Intrusive and Sedimentary Rocks." *The Naturalist* for 1899, pages 53-58, 149-154, 1899.

— "Norwegian Rhomb-Porphyries in the Holderness Boulder Clays." *Proc. Yorks. Geol. Poly. Soc.*, vol. xiii., pages 279-281, 1898.

HEDDLE, Prof. M. F. "The Minerals of the Storr [1856]." *Trans. Edinb. Geol. Soc.*, vol. vii., pages 328-331, 1899.

HERDMAN, Prof. W. A., and J. LOMAS. "On the Floor Deposits of the Irish Sea." *Proc. Liverpool. Geol. Soc.*, vol. viii., pages 205-232, 1898.

HILL, C. BASTIAN. "The Lower Palæozoic Rocks of the South of Scotland viewed in connection with the Lower Palæozoic Rocks of Cornwall." *Trans. Cornw. R. Geol. Soc.*, vol. xii., pages 258-277, 1899.

HIND, Dr. WHEELTON. "The Subdivisions of the Carboniferous Series in Great Britain and some of their European Equivalents." *Trans. Edinb. Geol. Soc.*, vol. vii., pages 332-360, 1899.

— "On the Correlation of the British and European Carboniferous Rocks." *Trans. Manch. Geol. Soc.*, vol. xxvi., pages 96-112, 1899.

— "What are the Real Equivalents of the Yoredale Rocks of Wensleydale in the Midlands?" *Trans. N. Staff. F.C.*, vol. xxxiii., pages 67-71, 1899.

HOLROYD, W. F., and J. BARNES. "On the Superposition of Quartz Crystals on Calcite in the Igneous Rocks occurring in the Carboniferous Limestone of Derbyshire." *Trans. Manch. Geol. Soc.*, vol. xxvi., pages 46-49, 1899.

HOPKINSON, JOHN. "The Chadwell Spring and the Hertfordshire Bourne." *Trans. Herts. N.H. Soc.*, vol. x., pages 69-83, 1899.

HOWARD, F. T. "The Geology of the Cowbridge District." *Trans. Cardiff. Nat. Soc.*, vol. xxx., pages 36-46, 1899.

— "Notes on the Geology of the Precelley Hills, Pembrokeshire." *Ibid.*, vol. xxx., pages 51-56, 1899.

— and E. W. SMALL. "Notes on the Geology of Llanvaches, Monmouthshire." *Ibid.*, vol. xxx., pages 30-35, 1899.

HUMPHREYS, JOHN. "Notes on the Geology and Botany of the Neighbourhood of Droitwich." *Trans. Woolhope N.F.C.*, 1895-97, pages 202-206, 1898.

JONES, Prof. T. RUPERT, JAS. W. KIRKBY, and Dr. JOHN YOUNG. "On Carbonia: its Horizons and Conditions of Occurrence in Scotland, especially in Fife." *Trans. Edinb. Geol. Soc.*, vol. vii., pages 420-442, 1899.

KEEGAN, Dr. P. Q. "On a certain Structure in the Lakeland Lavas." *The Naturalist* for 1898, pages 365-367, 1898.

KIRKBY, JAMES W. "On the Occurrence of Carboniferous Limestone Fossils at Viewforth, near Largo, Fife. *Trans. Edinb. Geol. Soc.*, vol. vii., pages 488-493, 1899.

KYNASTON, HERBERT. "Contributions to the Petrology of the Cheviot Hills." *Ibid.*, pages 390-415, 1899.

LA TOUCHE, REV. J. D. "Pot Holes and the Erosion of Rock Basins." *Trans. Woolhope N. F. C.*, 1895-1897, pages 170-176, 1898.

LAW, ROBERT. "Sketch of the Geology of Shibden." *Halifax Naturalist*, vol. iii., pages 97-102, 1898.

LAWRANCE, DAVID H. "The Kalgoorlie Mines of the Great Western Australian Gold Backbone." *Trans. Inst. Min. Eng.*, vol. xv., pages 436-441, 1898.

LOBLEY, PROF. J. LOGAN. "The Place of Geology in Education." *Trans. S.-E. Union*, vol. iii., pages 54-64, 1898.

LOMAS, J. "Do the Crystalline Gneisses represent portions of the Original Earth's Crust?" (Presidential Address). *Proc. Liverpool Geol. Soc.*, vol. viii. pages 179-180, 1898.

LOTT, FRANK E. "Burton Waters—Drinking and Brewing." *Trans. Burt. N. H. Arch. Soc.*, vol. iv., pages 5-31, 1899.

MACKIE, DR. WM. "The Felspars Present in Sedimentary Rocks as Indicators of the Conditions of Contemporaneous Climate. *Trans. Edinb. Geol. Soc.*, vol. vii., pages 443-468, 1899.

MANTLE, H. G. "The Skiddaw Granite of Syning Gill, Cumberland." *Proc. Birm. N. H. Phil. Soc.*, vol. xi., pages 1-5, 1899.

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EXPLANATIONS.

The — at the beginning of a line denotes the repetition of a word; and in the case of Names, it includes both the Christian Name and the Surname.

Discussions are printed in *italics*.

The following contractions are used:—

C.—Chesterfield and Midland Counties Institution of Engineers.

M.—Midland Institute of Mining, Civil and Mechanical Engineers.

S.—Mining Institute of Scotland.

N.E.—North of England Institute of Mining and Mechanical Engineers.

N.S.—North Staffordshire Institute of Mining and Mechanical Engineers.

S.S.—South Staffordshire and East Worcestershire Institute of Mining Engineers.